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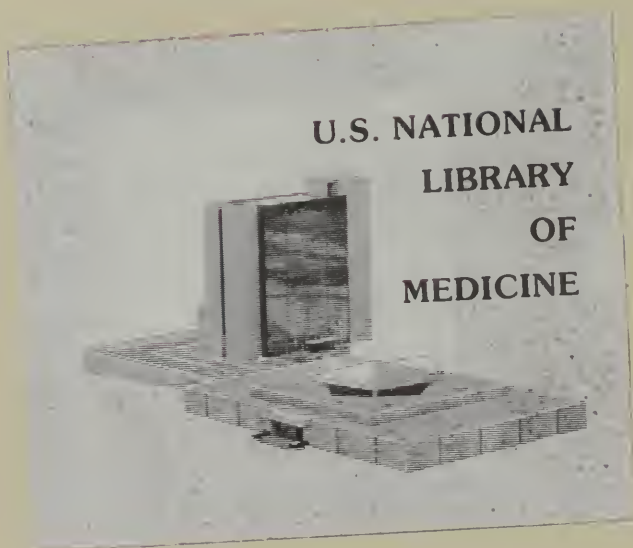
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# ELECTRICITY

IN

## DISEASES OF WOMEN AND OBSTETRICS.

BY

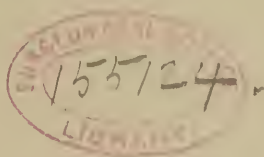
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WITH ILLUSTRATIONS.

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THE W. T. KEENER COMPANY,  
96 WASHINGTON STREET.  
1893.

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## PREFACE TO SECOND EDITION.

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The present edition is enlarged and revised. Four new chapters have been added: Chapter XXX.—General Galvanization and General Faradization. Chapter XXXI.—The Electric Bath. Chapter XXXII.—Static Electrotherapeutics; and Chapter XXXIII.—Summary of Treatment of General Diseases. Thus, while the book purports to be a work on Electricity as applied to Diseases of Women and Obstetrics, these added chapters give it a wider scope inasmuch as they give a general summary of all diseases for which electricity is applicable except those coming under special heads, as diseases of the eye and ear, and those diseases peculiar to the male. The chapter on rectal diseases has been revised by my friend, Dr. J. B. Bacon, and new matter on the treatment of hæmorrhoids added.

I take this occasion to thank the profession for the hearty reception they have given my first edition. I only hope that the work merits a small portion of the confidence that my friends have accorded it.

FRANKLIN H. MARTIN.

Chicago, April 1, 1893.



## PREFACE.

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This book has been written as a text-book for students and practitioners of medicine. The author's ideal of a text-book is one which considers each subject of which it treats from its primaries to the arrangement of primaries into principles, and finally to the practical application of such principles to the subject in hand; this evolution must be accomplished without traveling too fast for the beginner or too slow for the advanced.

Fully one-third of this book is occupied with presenting the primaries of electricity, of arranging these primary facts into laws, of developing these known laws into principles which may be depended upon to accomplish results. Nothing is more distasteful, at this time in medicine, than empiricism. Physicians now are more desirous than ever before to know the reason of things. In this portion of the work the author has made every effort to define principles, so that when they are applied in the more practical portion the "reason why" may be apparent.

Another third of the book is occupied with illustrations and apparatus. In this the commercial world has been liberally drawn upon for its contributions. The incandescent street wire, the dynamo and the storage cell, each have been compressed into the comparatively small but constantly increasing requirements of the physician.

The remaining third of the book deals in the application of the principles laid down in the earlier portions to the

practical treatment of diseased conditions. The author in this place has spared no pains at the risk of becoming tiresome of dwelling upon the minutest details of an application. The methods of procedure in the treatment of every condition is dwelt upon at length. Nothing is taken for granted. The author here has followed, with few exceptions, details which have proved successful in several years of a large hospital and private practice in gynecology.

Finally the author wishes to acknowledge the inestimable boon conferred upon modern gynecology by the genius of Dr. Georges Apostoli. Without his labors and investigations, this work would have been impossible.

FRANKLIN H. MARTIN, M. D.

Chicago, July 1, 1892.

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MEDICAL AND SURGICAL ELECTRICITY  
IN  
DISEASES OF WOMEN AND OBSTETRICS.

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PART FIRST.

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CHAPTER I.

It is as necessary for the student of medicine to master the principles of electricity, before he can become a competent electro-therapist, as it is for him to master his *materia medica* before he can hope to become a competent medical therapist.

Realizing, however, the vastness and intricacy of the subject, it shall be my endeavor to present those principles only which are absolutely necessary for an intelligent and practical comprehension of electro-therapeutics in its present state of advancement; being content to refer the reader to other works devoted to electricity for unimportant theoretical elaboration.

Electricity is a force like heat; that is recognized alone through its phenomena. We have no conception of it except as it is manifested in electrified bodies, either at rest or in motion.

To facilitate a better understanding of this subject, as manifested in its phenomena, we will consider it under the three heads of Magnetism, Statical Electricity, and Dynamical Electricity.

## MAGNETISM.

The word magnetism is derived from a Greek word, which was applied to an iron ore that possessed a remarkable attractive power for iron. This peculiar ore is supposed to have been discovered at Magnesia, in Lydia. The Greeks and Romans were not only aware that loadstone possessed the peculiar quality of attracting iron, but that it also had the power of imparting this quality to the iron with which it came in contact.

The first practical outcome from magnetism was the discovery of the mariner's compass. While, according to some authorities, this instrument was invented in China B. C., the first real historical account found of it in Europe was about the twelfth century. It is then described as a very crude, but not a new instrument.

From an examination of the mariner's compass, we discover two facts of importance:

1. Loadstone has the property of imparting its peculiar quality permanently to iron.
2. Loadstone, or a magnet, when suspended by its center, will assume a definite relation with the geographical meridians, one end of it pointing to the north, the other to the south.

The different conditions of the two ends of a magnet that determine one end to point to the north and the other to the south, is called its polarity; and the two ends of the magnet are called, respectively, the north and the south poles.

If a bar magnet is rolled in iron filings, the ends will be found thickly covered with a firmly adhering layer of the filings, these gradually growing fewer and less firmly adherent, until the center of the bar is reached, where none will be found. The points of greatest attraction are the respective poles, while the point of minimum attraction is called the neutral zone or point of indifference.

#### MAGNETIZATION.

1. The simplest method of magnetization is called "magnetization by single touch." To accomplish this, the bar to be magnetized is laid on some firm substance and the magnet held in a sloping position, is drawn over it many times, always in the same direction and with the same pole. The bar will now be found to be a magnet.

2. Magnetization by double touch is accomplished by laying the bar to be magnetized upon the table and rubbing it with two magnets. These magnets are placed so that one end of each magnet will rest near the middle of the bar, one having its positive pole in contact and the other the negative; they are then drawn in opposite directions until they slip over the ends of the bar, when they are again replaced and the process is repeated a number of times, until the steel bar is found to be a more or less powerful magnet.

3. By the galvanic current, magnetization is accomplished by moving the substance to be magnetized backward and forward through a coil of insulated wire, through which a current of electricity is passing.

4. The earth as a magnet inductively imparts magnetization.

#### PERMANENT MAGNETS.

Permanent magnets are bodies which possess permanent magnetic properties not depending on the circumstances in which they are placed.

#### MAGNETIC INDUCTION.

If a bar of soft iron is brought into a magnetic field, or in contact with a magnet, it will acquire magnetic properties; it will attract iron filings, and in every way possess the properties of a permanent magnet. This bar of soft iron, in other words, has become a magnet by induction. When a magnet by induction is removed from the magnetic

field or from the permanent magnet, it loses its magnetic property. It is called, therefore, a temporary magnet in contradistinction to a permanent magnet.

The two poles of a magnet have equal attractive power.

This is determined by floating a magnet in water on a piece of cork. If either the north or the south pole had an excess of attractive power over the other, the cork would traverse the water in the direction of that particular pole. This it does not do; the magnet assumes immediately a north and south position and there remains stationary.

If a magnet is divided many times, each piece will have a north and south pole whose strength is equal to that of the poles of the original magnet.

#### MAGNETIC FIELD.

Any region where forces act is called a field of force. If the forces are magnetic, it is called a magnetic field. When the direction and magnitude of the magnetic forces are equal, the region is called a uniform magnetic field.

If a table is taken so that a compass needle points along it, at all points just above this table, there will be a constant magnetic force parallel to the length of the table and in the direction of the needle.

#### COUPLE.

Now the force acting on any compass needle or magnet on the above table is called a couple, because it acts equally but in opposite directions on each pole. I borrow the following definition of a couple, together with its illustration from Gordon:<sup>1</sup>

A couple consist of two equal and opposite forces, acting on a body in directions which are parallel but do not coincide. It is obvious that a couple cannot move a body but only cause it to revolve. The force acting on a water

<sup>1</sup>Electricity and Magnetism, Vol. I., page 149.

wheel is a good instance of the couple. Neglecting for a moment the weight of the wheel, we see that, if there were no axle, the force of the water acting at Fig. 1, would simply carry the wheel down the stream. When, however, an axle is inserted at O, then, in order to prevent the wheel being carried down stream, the bearings of the axle have to press on it with a force equal to that exerted by the water, and in an opposite direction. Here there are two equal forces forming a couple, and their effect is to make the wheel revolve.

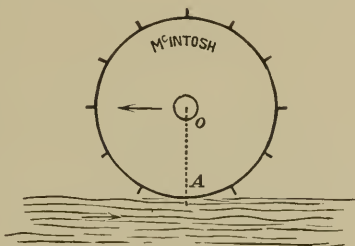


FIG. 1.

Hence, it is easy to understand that a magnet in a uniform magnetic field is subject to just such a couple when in any position except parallel to the lines of force. If it is in any other position, and it is free to move, it will very soon assume a position parallel, when the direction of the two forces coincide, and necessarily the couple disappears.

#### MOMENT.

The moment of a magnet is the directive force of a magnet in any field, as it is manifest in the force exerted by a torsion thread to keep the magnet in its first position.

*The moment of a couple, is the strength of either of its equal forces, multiplied by the perpendicular distance between the lines, which represent their direction and pass through their points of application.*

*The combined moment of a number of pieces of a magnet, is equal, exactly, the moment of the magnet when whole.*

*Magnetic potential of a given magnetic pole is of exactly the same nature as that due to an electrified body at that place.*

## THE UNIT OF MAGNETIC MOMENT.

*The unit of magnetic moment, is the moment of a magnet whose length is one centimetre and the strength of whose poles, will repel a similar pole, one centimetre, with a force of one dyne.*

## INTENSITY OF MAGNETIZATION.

By doubling the length of a magnet, its magnetic moment is doubled, because while leaving the strength of poles the same, the arm of the couple bar has been doubled.

By doubling the section of a magnet without disturbing its length, its magnetic moment is doubled. Here, as in doubling its length, the volume is doubled. If both the length and cross section of a magnet is doubled, the magnetic moment and the volume is quadrupled. Hence,

*The magnetic moment of any one of a number of uniform magnets is exactly proportionate to its volume.*

*The unit of intensity of magnetization is the intensity to which a substance must be magnetized, that a cubic centimetre of volume of it will repel a similar pole distant one centimetre with a force of one dyne.*

## INTENSITY OF MAGNETIC FIELDS.

*A magnetic field of unit intensity, is a field where a unit pole will be acted on with a force of one dyne.*

## CHAPTER II.

### STATIC ELECTRICITY.

If a piece of sealing wax and glass are both rubbed quickly with a piece of woollen cloth, they will acquire the property of attracting and repelling certain small particles in the neighborhood. While this phenomenon at first sight resembles the attracting and repelling power of the magnet, it is by no means the same, and is definitely distinguished from it: 1st, By its origin—the above phenomenon being brought about by friction or other causes in a large number of indiscriminate substances, while magnetism is confined to loadstone and other combinations of iron ore, iron, nickel, cobalt, and other metals. 2nd, Every magnet possesses two poles, each having an opposite action, one repelling, the other attracting the substances acted upon, while an electrified body may possess the same property upon its entire surface. 3rd, A magnet exhibits its properties upon magnets and their equivalents, as iron, nickel, cobalt, etc., while excited glass or wax will attract light particles of any substance.

#### PROPERTIES OF ELECTRIFIED BODIES.

1. The power of attracting or repelling other electrified bodies.
2. The power of transmitting similar properties to other bodies.
3. The power of attracting uncharged bodies.
4. The power of giving off sparks when powerfully electrified.

## A SIMPLE METHOD OF ELECTRIFYING BODIES.

If a rod, of glass or of sealing wax, be rubbed with a dry handkerchief it will be electrified.

It will be found by experimenting with sticks of sealing wax thus electrified, that they repel each other; the same is true of two pieces of glass. If, on the other hand, an electrified rod of sealing wax is brought near to an electrified glass rod, the two will strongly attract each other.

Thus, we find the two bodies possessed of different properties, or, in other words, different kinds of electricity, those of like properties repelling each other and those of unlike attracting each other.

It will be found in *all cases* there are two kinds of electricity, one like that possessed by rubbing glass, and one like that possessed by rubbing sealing wax; that similar electrifications repel each other and unlike attract each other.

## KINDS OF ELECTRICITY.

If equal quantities of electricity produced by glass, and electricity produced by sealing wax, be brought together, they will neutralize each other.

For the above reason, the glass electricity and sealing wax electricity are called respectively *positive* and *negative*, written (+) and (-).

**Light bodies**, as feathers or small pith balls, are acted upon alike, viz., attracted by both a negatively or a positively charged body.

## ELECTRIFICATION.

When a rod is electrified by friction of any material, the material used for the purpose will be found to be charged with an equal amount of electricity, but of opposite tendency to that imparted to the rod.

## TRANSFER OF ELECTRIFICATION.

If a body charged with electricity is brought in contact with an uncharged body, the first will lose its electricity to the second, until they become neutralized. The quantity of electricity transferred in such a contact depends upon the size of the two bodies. If they are spheres, the electricity will divide between them in proportion to their radii.

## INSULATORS AND CONDUCTORS.

If an end only of a rod of sealing wax or hard rubber be electrified, it will be found by experiment that the opposite end, if kept in dry air, will remain unelectrified for a long time, while, on the other hand, if the end of a metal rod be electrified, it will be found immediately, that this electricity is distributed all over its surface.

Substances like the first, rubber, sealing wax, glass, etc., in which electricity does not move rapidly, are called insulators.

Substances like the latter, as silver, iron and the other metals, in which electricity moves freely, are called conductors.

Dry air is the best insulator known and silver is the best conductor. Between these two extremes range all other substances; there being no definite line of demarkation between the insulators and the conductors. For practical purposes, however, those near the dry air end of the list as air, glass, ebonite, sealing wax, etc., may rank as insulators; while those at the silver end of the list, the metals, may rank as conductors.

## GOLD LEAF ELECTROSCOPE.

The electroscope is a delicate device for determining the presence of electricity in any charged body.

Fig. 2 shows a gold leaf electroscope (Gordon). The large round plate at the top is connected with the two

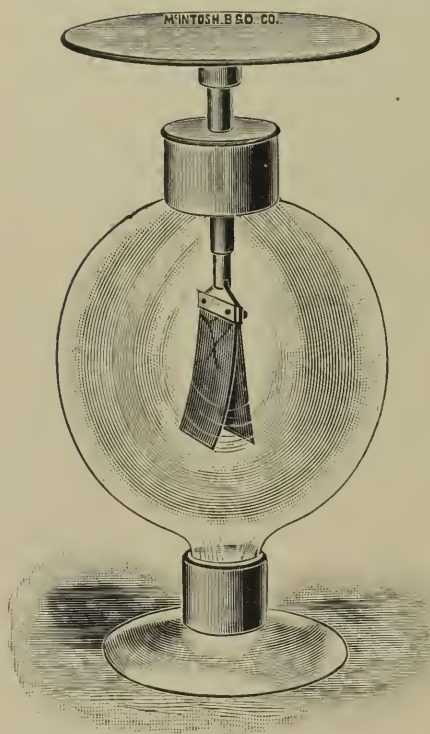


FIG. 2.

pieces of gold leaf suspended in the glass jar by means of the connecting brass rod, passing through a hole in the top of the jar. If a charged body of any kind is brought in contact with the metal plate above, by a transfer of electricity the two pieces of gold leaf will become charged with the same kind of electricity, will immediately repel each other and consequently their free ends will become separated. Owing to the lightness of gold leaf, this is a very sensitive instrument for detect-

ing the presence of the smallest quantity of electricity.

#### ELECTRIFICATION BY INDUCTION.

As we found in magnetism that metals became magnetized by induction, so here we find that bodies become electrified by induction. When a charged body is placed near another, which is not charged, and not in actual contact, the uncharged body acquires an electrified condition, and remains so until the charged body has been removed from the neighborhood, when its electricity rapidly dis-

appears. This kind of electrification is called electrification by induction.

**Experiment.**—<sup>1</sup>Rub glass, or a wax rod, and hold it near to, but not in contact with the plate of the electroscope described above; the gold leaves will be found to immediately separate. On removing the rod from the vicinity the leaves again collapse. This experiment demonstrates that the rod induced a charge in the plate and gold leaf across the intermediate space of air.

It is found that a metal screen connected with the earth if inserted between the electroscope and a charged rod, will prevent induction.

#### PROOF PLANE.

A proof plane is a metal disk connected with an insulated handle. By means of this simple device, a portion of a charge from any body, or any part of a body, can be carried to the plate of an electroscope and discharged.

#### INDUCED CHARGES.

An induced charge invariably consists of two kinds of electricity. The electricity arranges itself on the body possessing the induced charge so that the electricity of opposite tendency occupies the portion of the body nearest to the induced body and that of like tendency occupies the portion of the body farthest from it.

In Fig. (3) the large body is charged with positive electricity. The small body lying in the immediate



FIG. 3.

vicinity of the large one has become electrified by induction. It will be seen that the end of the small body nearest the large one is marked negative and the distal

<sup>1</sup>Gordon.

end is marked positive. That two kinds of electricity are present in bodies charged by induction, and that the electricity is arranged as Fig. (3) indicates, can be proven by the following experiment :

Touch the middle of an induced body as represented in Fig. (3) with a proof plane, and then bring the plane in contact with an electroscope. No effect will be produced upon the gold leaves; this indicates that the middle of the body, the portion touched, contains no electricity; the induced charge, then, must necessarily be at the end. This fact can be proved by touching the two ends respectively with proof planes, and carrying them to two electroscopes respectively, when the gold leaves in each will immediately diverge. Now, to prove that the two ends of the induced body contain opposite kinds of electricity, we have simply to bring together the plates of the two electroscopes, when the gold leaves in each will suddenly collapse, the positive electricity of one neutralizing the negative of the other.

If a small pith ball charged from a large inducing body, Fig. (3), is brought in the vicinity of the distal end of the induced body, it will be repelled. This indicates, of course, that the portion touched is charged with the same kind of electricity as the inducing body. The proximate end, then, must necessarily be charged with an opposite kind of electricity. If we now remove the body A, or which amounts to the same thing (as we will see later), connect it with the earth, so that it will discharge its electricity, the induced body, B, will also immediately lose all traces of electrical action.

#### EARTH CURRENTS.

If an electrified body becomes connected with the ground, its electricity immediately becomes neutralized with that of the earth, and practically, it may be said that its electricity has escaped to the earth.

## ELECTRICAL DISTRIBUTION.

Experiments point to the conclusion that electrical distribution in conducting bodies depends on the shape of their exterior. In other words, the electricity of an electrified body is confined to its surface.

## COULOMB'S EXPERIMENT.

Coulomb took a hollow sphere, in the top of which an opening was left, and caused it to be electrified. By means of a proof plane, the interior of the sphere was carefully tested, and it was found to contain no electricity except very near the edge of the opening. Hence, it is safe to conclude that if the sphere had been closed entirely, there would have been no electrification of the interior.

## DENSITY.

The more intensely any body is electrified, the more electricity to the square inch of its surface will it contain. The intensity of electrification of any point of an electrified body is called its electric density.

*The electric density of any point of a sphere is in direct proportion to the density of the whole sphere.*

An ellipsoid electrified, however, does not show this equal distribution, the tendency here, is for the electricity to accumulate with greater density at the sharp edges or ends of the major axis, with a gradual shading off to the equator, and the ratio of density increases as the ellipsoid is made sharper. Hence, it is always found that electrical density is always very much greater at a pointed part of a conductor.

## POINTED CONDUCTORS.

Electricity escapes more rapidly from a pointed conductor than from a rounded or blunt one.

## FRICTION MACHINES.

All friction machines consist essentially of three parts:

- 1st. The rubbed body.
- 2nd. The rubbers.
- 3rd. The conductors and collectors.

## A SIMPLE FRICTION MACHINE.

Machines for collecting electricity by rubbing silk and glass together are made in several forms. Fig. 4 shows one of the simplest of these machines.

## THE GLASS PLATE MACHINE.

This machine (Fig. 4) is a circular plate of glass fixed in a frame so that it can be rapidly turned on its axis by means of a handle.

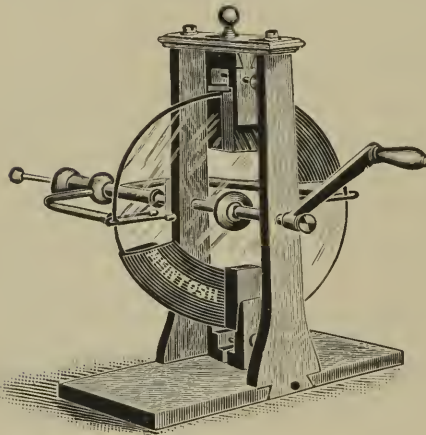


FIG. 4.

Pressing upon it near its edges, are two cushions which are connected with the earth for the purpose of carrying off the negative electricity to the ground, which accumulates upon them. The glass, in the meantime, becomes highly charged positively, but its electricity has no

means of escape, but by the points of a large conductor, which is attached to the frame. This conductor is in massive brass, and the electricity escapes through it by means of conducting points which barely touch the glass. If the machine is rapidly turned, the glass plate and the connecting conductor becomes highly charged with positive electricity, which may be drawn off by bringing the knuckles, or any

conductor, near the accumulating brass balls of the machine. The discharge will be accompanied by an audible report and a brilliant spark.

#### ELECTRICAL ACCUMULATORS.

An accumulator is an apparatus for collecting quantities of electricity.

#### LEYDEN JAR.

Leyden and Kleist invented, independently, the Leyden jar about the same date. It is made of a wide mouthed bottle of hard white glass, coated inside and out with tin foil (Fig. 5). A large wooden stopper is fitted in the top through which passes a brass rod terminating at the top in a knob and to the other end in the bottle, is attached a brass chain which comes in contact with the tin foil lining the interior.

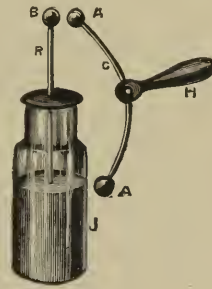


FIG. 5.

The inside coating or tin foil of the jar can be charged with positive electricity by bringing the brass knob in contact with the conductor from a friction machine. We know that the interior is of the same potential, or charge, as the conductor when sparks no longer pass between the conductor and the knob of the jar. This positive charge acts inductively upon the tin foil on the exterior of the jar, and induces a negative discharge on the inside of it, which is in contact with the glass, and a positive charge on its outside.

If now, the outer conductor be connected with the earth, the side farthest from the inner conductor may be said to be indefinitely separated from it, and the outside conductor or tinfoil may be said to be negatively charged. As the outside tinfoil entirely surrounds the other, the induced negative current is exactly equal to the induced positive current.

Thus we have two distinct charges of electricity of opposite kinds spread over the two surfaces insulated from each other by a very thin plate of glass.

#### EXPERIMENT.

Take a discharger (Fig. 5) H, which consists of a curved brass rod terminating in two knobs and connected at the middle with an insulated handle, and touch the outside coating of the jar with one end of the discharger and bring the other gradually near the knob. Here we have two strains going on, one of the glass between the two dischargers, and another of the air separating the knob of the bottle and the knob of the discharger. The first is constant, the latter is growing more and more intense, as the space between the conductor is made shorter, until at last its mechanical strength gives way and the electricity bursts through it with a flash and a report; the negative electricity on the outside of the bottle has become neutralized by the positive from within, and the bottle is completely discharged.

#### RESIDUAL CHARGE.

In a short time, if the jar is left to itself, it will be found to contain a second charge brought about by a reaction between the molecules of the glass that had been in a state of great strain or tension.

The discharge of the Leyden jar is analogous to the flash from a thunder cloud. The earth and the cloud correspond to the two surfaces of the jar, charged with opposite electricity, separated by a layer of air, a tree, or some projection acts as the discharger.

#### POTENTIAL.

Static electricity represents an immense potential or power of overcoming resistance. It escapes from conductors in three ways:

First, By conduction. This is when it passes quietly from a machine by actual contact of a conductor.

Second, By disruptive discharge. This occurs when there is great accumulation in a machine or accumulator, and by great force it breaks loose accompanying its discharge with a spark and a loud report.

Third, By conviction. This occurs when there is a great accumulation of electricity in a conductor with much strain, when a constant passage of electricity through the surrounding particles of air takes place and is swept away by the electric wind which it creates, and which is an essential part of the phenomenon.

#### CAPACITY.

The capacity of a condenser (a Leyden jar is sometimes called a condenser) is measured by the quantity of electricity of unit potential which it will contain; or it is equal to the charge divided by the potential.

#### ELECTRICAL MACHINES.

Since the first machine for producing frictional electricity was invented by Otto Von Guericke, in 1672, we have had a great variety. This first one, of which we have record, was constructed of a globe of sulphur on a wooden axle and handle, by which it could be turned, so as to be rubbed by a cloth pressed against it by the hand. The glass cylinder and the glass plate followed this, and other improvements followed, but owing to the uncertainty of these machines in changes of weather, they were much neglected for some time after the discoveries of Galvani and Volta of the galvanic battery. Later, however, Franklinism was revived, and the valuable improvements in the electrical machines to which Holtz and Topley added much, were ushered in.

## MACHINE FOR MEDICAL PURPOSES.

The machine represented in cut 6 is an improved Topler Electric Machine which, to my mind, is one of the best representations of a complete medical electric machine that we have.

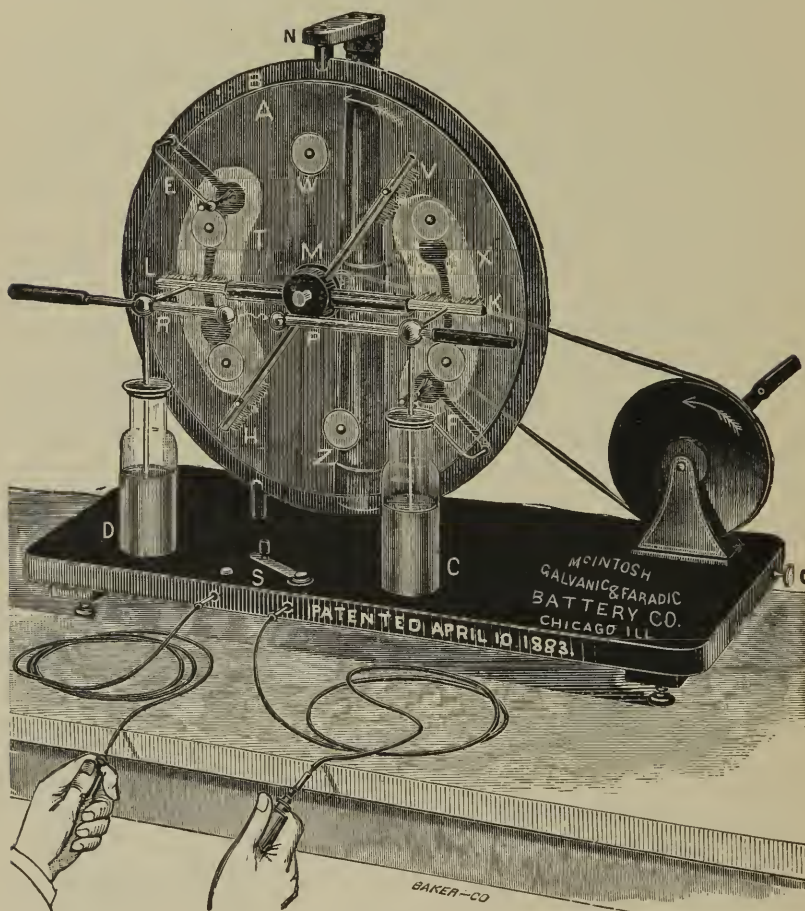


FIG. 6.

## THE MEDICAL ELECTRIC MACHINE.

Size of base, 12x26 inches.

B, stationary plate supported by hard rubber insulators.

N, cap with rubber insulator to hold upper end of B firmly in place.

A, revolving plate  $\frac{1}{4}$  inch from B.

M, axis on which A revolves. It is attached to the upright post through an opening in the center of plate B.

E, and F, brushes attached to plate B through holes near its edge.

T, and X, tin foil and paper inductors on the surface of plate B, next the upright post which supports it.

The tin foil inductors are represented by the dark shade, and the paper inductors by the light shade.

V, and H, uninsulated combs with brushes in front of A,  $\frac{1}{4}$  inch from its surface. They are screwed to a brass core at the center of the hard rubber disc M.

D, and C, Leyden jars.

P, and R, rods sliding through the knobs which convey electricity to the internal coating of the Leyden jars.

L, and K, insulated combs connected with the sliding rods P and R.

W, and Z, two of the six discs or carriers attached to plate A.

S, the switch for obtaining the induced current from the outside coating of the Leyden jars.

O, adjusting screw to tighten or loosen the belt. The arrow indicates the direction the drive wheel must be turned.

#### THEORY OF ACTION.

First, to generate electricity, we must obtain a means of creating a difference of potential between two bodies.

Second, we must be able to maintain a difference of potential between these bodies when they have become connected.

Third, the connection between the two bodies of unequal potential seeks to establish an equilibrium by conducting the electricity from the body of higher potential to that of lower, and thus an electric current is established, which will continue as long as the force is acting, which keeps up a difference of potential between the two original bodies.

#### HOW TO CARE FOR AN ELECTRICAL MACHINE.

Keep in a dry place. It should be kept in a glass case, from which the moisture can be dissipated in damp weather by heating the contained air with a gas lamp if necessary; especially should this be done if the machine

does not work readily. The lamp should be removed from the case as soon as sparks are obtained by operating the machine. A small lump of unslacked lime kept in the case, will have a tendency to keep the machine dry. The case also protects the machine from light particles floating in the air which are attracted by it while in active operation.

## CHAPTER III.

### GALVANISM OR DYNAMICAL ELECTRICITY.

In 1790, Galvani made his great discovery, that the contact of metals produced muscular contraction in the frog's leg. In 1800, Volta invented the voltaic pile. The result of these two discoveries gave us Galvanism or voltaic electricity, and from them rapidly developed the modern science of dynamic electricity.

If two separate bodies are of a different potential, or electrical condition, and they become connected by a conductor, we have seen that there will be a flow of electricity through the conductor from the body of higher potential to that of the lower. Now, if we devise some means by which these bodies will have a tendency to remain at a difference of potential, there will be a constant flow of electricity in the conductor connecting them. This flow of electricity, from one to the other body along the conductor, is called an "electric current," and invariably manifests itself on any conductor connecting two bodies of unequal potential.

A device that will have a tendency to keep two bodies of unequal potential so that when connected an electric current will flow as long as the device is in action, is represented in its simplest form in the voltaic pile.

**The Voltaic pile.** Fig. 7. The principle of the voltaic pile or battery is as follows: If two different metals are immersed in a solution that will act chemically upon them,



FIG. 7.

and the solution acts more rapidly upon one than upon the other, the two metals will assume different electrical potentials. The one least acted upon having the greater potential. This difference of potential depends not upon the size or position of the plates, but upon the metals and the solution.

Shortly, these metals will reach their constant potential value, and then the chemical action will cease. Now, if the metals are connected outside the liquid, by a conducting wire, the electricity from the metal of higher potential flows in a current through the connecting wire to the metal of lower potential. This disturbs the equilibrium of potential between the two metals, and the chemical action again recommences and will continue as long as the metals are connected externally by the wire, or until the metal most acted upon is destroyed.

The voltaic pile, as originally constructed (Fig. 7), consisted of pairs of copper and zinc plates, separated by pieces of blotting paper moistened with dilute acid or a saline solution. These were arranged, alternating the zinc and copper plates, so that, when completed zinc occupied one end and copper the other end of the pile. A copper wire conductor connecting the two ends of the pile, permitted a flow of electricity, whose current was proportionate to the number of pairs of plates.

The metal least acted upon in a voltaic couple or galvanic cell, constitutes the positive (+) pole, and the one least acted upon the negative (−) pole of the battery, and the current of electricity will flow in the external circuit, in a direction from the positive to the negative pole.

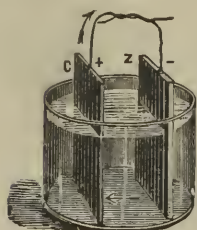


FIG. 8.

The simplest form of a voltaic cell is represented in Fig. 8. Two pieces of metal—one zinc, the other copper,—are partially immersed in a dilute solution of sulphuric acid. This arrangement gives a current of electricity in the external circuit, in the direction from the

copper to the zinc, which, however, gradually becomes less and less, until there is no longer any current perceptible. If we look for the disturbing cause, we will find upon examination of the copper that it is completely covered with minute bubbles, which will prove if tested to be hydrogen gas. This is caused by the decomposition of the water in the solution, the oxygen combining with the zinc, and the hydrogen, as it is set free, adhering to the surface of the copper. The effect of the copper being coated with hydrogen, is to equalize the potentials between the metals.

We have assumed that the metals used in the batteries are free from impurities. This is, however, seldom the case, and it is necessary, therefore, to take this point into consideration, in order to understand some of the peculiarities of batteries. The ordinary commercial zinc, of which battery plates are constructed, contains many particles of impurities—iron and other metals. When the zinc plate, therefore, is immersed in the battery fluid, these particles of impurities each assume a difference of potential, and small currents are established in every direction between them and the neighboring zinc. These small circuits are a hindrance to the complete action of the battery and the difficulty should be obviated.

As it is impracticable to use chemically pure zinc in making ordinary batteries, on account of its expensiveness, another means is adopted which has been found equally efficacious.

#### AMALGAMATION.

This consists in coating the zinc with mercury, which is accomplished by immersing the plate in dilute sulphuric or hydrochloric acid until it presents a clean surface, when it is brushed with mercury until it assumes a bright silvery appearance. Zinc thus amalgamated, is not attacked by dilute sulphuric acid when in action in the battery.

## THE GENERATING PLATE.

The generating plate of the battery is the one most acted upon chemically, and in the case of zinc and carbon, is the zinc. The chemical action upon this plate in the battery, by the exciting fluid, causes a liberation of electricity from its surface.

## THE CONDUCTING PLATE.

The conducting plate of the battery is the one least acted upon chemically, and in the case of zinc and carbon, is the carbon. This plate collects the electricity and assumes an electrical tendency greater than the generating plate.

## ELEMENTS.

A generating plate and a conducting plate, form an essential part of a battery and are, therefore, called the elements, and when combined or coupled, are called a pair of elements.

## A COMPOUND BATTERY.

Two or more pairs of elements coupled together constitute a compound battery. Fig. 9 represents such a battery in its simplest form. Here, the collecting element, copper or carbon, of one cell, is connected by a short wire with the generating element, zinc, and the current passes in the direction indicated by the arrows.

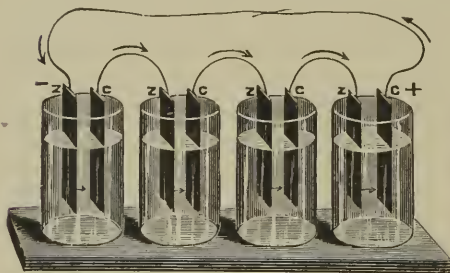


FIG. 9.

## THE CIRCUIT OF A BATTERY.

The circuit of a battery includes the course that electricity will pursue in passing from a given element through the other elements, the fluid, all of the internal connec-

tions, the external connections, back to the starting point. This includes, also, any intervening body with which the free ends of the wires may be in contact.

**Short Circuit.** When the first element and last element are connected with a short wire, as in Fig. 9, the battery is said to be short circuited. A battery is short circuited, also, when a current acts between its elements even when not externally connected.

**Closed Circuit.** A battery is said to be closed circuited, when its last element and its first element are connected outside the battery by any form of conductor.

**Open Circuit.** When there is no external connection between the two ends of a battery, or when the connections are broken, the battery is said to be open circuited.

#### THE POLES OF A BATTERY.

The points of the battery at which the current leaves and enters it are called the poles. The point at which the current leaves the battery is called the positive pole, and the point at which it enters it is called the negative pole. The direction of the current in the battery is from zinc to copper, and in the external circuit from copper to zinc.

#### POLARIZATION OF BATTERY CELLS.

When zinc and copper are immersed in dilute sulphuric acid, a chemical action is immediately set up between the plates and the fluid. The sulphuric acid of the fluid attacks the zinc plate and a portion of it is dissolved; this chemical action in turn creates a current of electricity, which passes from the zinc to the copper. The electricity, by chemical action, called electrolysis, resolves a portion of the water of the fluid into its constituent elements, hydrogen and oxygen. These elements as they are liberated, in the form of gas, are respectively attracted to the positive and negative elements of the battery. This is because oxygen is a negative element and hydrogen a positive ele-

ment and opposite kinds of electricity attract each other. As the negative oxygen appears at the positive zinc (that is zinc is positive in the fluid) it combines and forms oxide of zinc, and this latter is immediately transformed into sulphate of zinc by the sulphuric acid. The positive hydrogen, on the other hand, which is attracted by the negative copper, forms upon the plate in little bubbles which shortly produce a coating over its entire surface.

As the copper plate becomes well covered with this film of hydrogen, it begins to change its electrical properties and will, in time, become the generating plate, converting thereby, the zinc, of necessity, into the collecting plate, and the current in the battery will be reversed. This is because hydrogen is more readily acted upon than zinc by the fluid of the battery. The battery is now said to be polarized. As this destroys its value, it is very necessary that some means be found to obviate the difficulty. This can be accomplished, to a great extent, by a number of different procedures. Shaking the elements will temporarily disengage the bubbles of hydrogen. Blowing air over the surface of the conducting plates will accomplish the same end. By adding certain ingredients to the battery fluid, as bichromate of potash, sulphate of copper, or nitric acid, the tendency to polarization is lessened. Two fluids, instead of one, are employed in some batteries, while in others elements of irregular surfaces are used, and, simply resting a battery will sometimes temporarily restore its action when stopped by polarization.

## CHAPTER IV.

### PHYSICAL PROPERTIES OF THE GALVANIC CURRENT.

When two bodies, like or unlike, come in contact there is a flow of electricity between them. If two bodies were identical in their molecular construction, if it were possible for their molecular arrangement to be absolutely the same, and further, if it were also possible for these bodies to be brought in contact without producing molecular vibration, then, theoretically, no current would flow between them. But as this condition never exists, we can assert the rule that there is always a difference of electrical condition between any two bodies, and in consequence of this, if two bodies come in contact there is a flow of electricity from the one of greater electrical tendency to that of the less until they become neutralized. The more unlike, in molecular arrangement, any two bodies are, the more unlike are their electrical conditions and the stronger will be the flow of electricity between them if they become connected.

The electrical condition of any body is called its *potential*.

Of two bodies of different potential, the one of greater potential is said to be positively charged, and the one of less potential to be negatively charged.

If a positively charged body becomes connected with one negatively charged, the electrical current will flow from the positive to the negative body, or from the one of greater potential to that of the less.

#### ELECTROMOTIVE FORCE.

The electromotive force of a current is determined by

the difference in potential of the two ends of the connecting medium. Let C, in figure 8, represent the carbon of a galvanic battery cell, and Z the zinc, both being immersed in a cup of dilute sulphuric acid. They immediately assume a difference of potential, that of the carbon becoming greater than that of the zinc. The carbon, therefore, becomes the positive (+) pole and the zinc the negative (-) pole, and the difference of potential represents the electromotive force of the current, which traverses the connecting wire in a direction from the + to the - pole.

#### RESISTANCE.

Resistance is the obstruction that a current of electricity encounters in traversing any conductor, or is that property of a conductor that determines the amount of electricity that shall traverse it from a given source.

Increasing the resistance of a conductor, decreases the current that will traverse it from a given electromotive force.

#### CURRENT.

Current, therefore, is dependent not only upon the electromotive force, but also upon the amount of obstruction that the electromotive force must overcome in making its circuit, hence —

#### OHM'S LAW.

Current is determined by dividing the electromotive force by the resistance, and is expressed by the following equation:

Ohm's Formula:

$$\text{Current} = \frac{\text{Electromotive force}}{\text{Resistance}} \text{ or } C = \frac{E}{R}$$

#### VOLT.

Volt is the term employed to express electromotive force. The standard of the volt is approximately represented by the electromotive force of a Daniell's cell.

# OHM.

Ohm is the term employed to express resistance. The standard of the ohm is represented by the resistance of a column of mercury 1 sq. mm. in area and 1.05 m. in length. A test for the ohm, more easily appreciated, is the resistance offered by a pure copper wire  $\frac{1}{16}$  of an inch in diameter and 960 feet long.

# AMPERE.

Ampere is the term employed to express current. The current derived from a Daniell's cell, or any cell of one volt electromotive force passing through a resistance of one ohm, for one second, represents an ampere. This is determined by Ohm's law which we have already given, thus: The electromotive force of a Daniell's cell is one volt, and we have a resistance of one ohm, by dividing the electromotive force, 1, by the resistance, 1, we get as a result, 1, which represents the current in amperes.

Thus, if we have a generator with an electromotive force of 10 volts, and the resistance met in the conductors by this force is 5 ohms, we have, by the Ohm's law, the following:

E expressed in volts, 10	=	2 expressed in
R expressed in ohms, 5		amperes.

Thus, we find that a current can be increased (1), by increasing its electromotive force, and (2), by reducing its resistance. As these two factors, electromotive force and resistance, must always be taken into consideration in determining the strength of a current, and as the resistance of different conductors, and especially the parts of the human body, which become a part of the circuit, must vary, it is difficult to estimate, even approximately, the current strength in a given case. When we take into consideration, too, that the electromotive force of different batteries, and even of the same batteries at different times, varies, we can realize the necessity of having an instrument which will indicate to us, at all times, the strength of the

current in the circuit. This is accomplished in the commercial world by the ampere meter. As a current of one ampere is too strong for therapeutic work, we take in medicine the milliampere, or the one thousandth part of the ampere, as the unit of current. All therapeutic currents, therefore, by common consent, are estimated in milliamperes instead of amperes, and the instrument for measurement is called the milliampere meter. Its convenience is shown by the following illustration: Let B, in

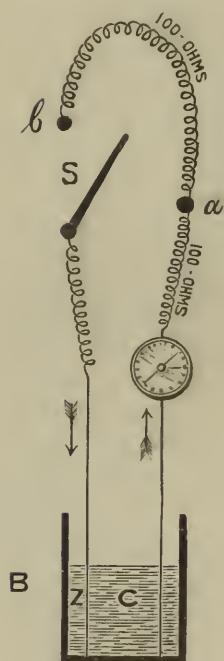


FIG. 10.

however, we can verify the indications of the milliampere meter by applying Ohm's law: When the milliampere meter indicated 10 milliamperes, switch S was connected at (a), and the circuit gave 100 ohms resistance. We, therefore, had the following equation:

Fig. 10, represent a battery cell of one volt electromotive force, Z the zinc, C the carbon element, M a milliampere meter, in the circuit, and S, a switch which will touch either a or b. If S is made to touch the point (a) the milliampere meter will register 10 milliamperes or  $\frac{1}{100}$  of an ampere, whereas, if the switch S is made to touch (b), the milliampere meter will register 5 milliamperes, or  $\frac{1}{200}$  of an ampere. The milliampere meter then, indicates to us the strength of current, rendering it unnecessary for us to solve the problem by mathematical calculation, which implies an exact knowledge of the electromotive force of our batteries as well as the precise amount of resistance in the circuit. In the above illustration,

$$\frac{1}{100} \frac{E}{R} = .01 \text{ or } 10 \text{ ma.}$$

In the second example we had an additional resistance of 100 ohms switched into the circuit, by connecting switch S with (b), and the following equation is the result:

$$\frac{1}{200} \frac{E}{R} = .005 \text{ or } 5 \text{ ma.}$$

#### RESISTANCE.

We have found resistance to mean, in electrical language, the property that any conductor has of obstructing a current in its passage through it. It is necessary for us to consider now, a little more in detail, this important factor.

Resistance varies: 1. With the quality of the conductor. 2. With its physical conditions. 3. With its form.

1. By quality is indicated the degree of conductivity shown by various forms of matter; as the difference between copper and platinum; between muscle and bone; between water and saline solution. For example, if a current of given electromotive force traversing a copper wire a thousand feet long gives 100 ma., a current of the same electromotive force traversing a wire of platinum of the same diameter and the same length, would give but 16 ma. This demonstrates that the resistance of copper is much less than that of platinum. A test of fresh muscle and bone would prove the bone to be of greater resistance. Water would be found to have many times greater resistance than a saline solution.

2. By physical condition of a conductor is meant its condition as to density, temperature, moisture, etc.

A copper wire of certain length and diameter will give less resistance than a bundle of muscular fibres of the same length and diameter, because the copper has greater muscular density. The copper wire will also offer less

resistance when at a low temperature than when at a high temperature. This can be explained by the fact that heat expands the metal, thereby rendering it less dense, and becoming less dense, its resistance increases. While this is true of metals, the opposite is true of liquid conductors. A hot saline solution is a much better conductor than the same solution at a lower temperature. Muscular tissue offers less resistance to electricity than connective tissue because 1, in its natural state it is more dense, and 2, it contains more moisture. A dry sponge offers almost infinite resistance, if its density is increased by moistening it with pure water its resistance is much reduced, while if it is moistened in water that has been rendered more dense by dissolving in it a saline, the sponge will offer a minimum resistance. Upon first applying a moist electrode to the dry skin, the resistance will be found to be enormous, until the skin begins to imbibe the moisture from the electrode, when the resistance will perceptibly and rapidly decrease.

3. By form is meant the relative dimensions of a conductor. Double the area of a cross section of conducting wire and its resistance is lessened one half. Double the length of the conducting wire and its resistance is doubled, hence: Resistance is increased in a direct ratio to the length, and in an inverse ratio to the cross section of a conductor.

The above law is applicable alike to solid and liquid conductors.

A pure copper wire 960 feet long and  $\frac{1}{10}$  of an inch in diameter, will offer a resistance to a current of electricity of one ohm. A copper wire of the same diameter and double the length or 1920 feet, will offer a resistance of two ohms. If, on the other hand, the first wire of 960 feet and  $\frac{1}{10}$  in diameter, be replaced by another wire the same length and double the sectional area, the resistance will be decreased to one half an ohm. This law is also

applicable to tissues of the human body when they become a part of the circuit of the battery. For example: If two electrodes, each having a sectional area of one inch, be placed on opposite sides of a portion of the human body, and the resistance be found 1000 ohms, by doubling the sectional area of the electrodes, everything else being equal, the sectional area of the conducting tissue is doubled and the resistance, therefore, is reduced one half, or to 500 ohms.

# RESISTANCE BOX.

Resistance is determined by means of a simple contrivance called a resistance box or bridge. It consists of a box in which a number of coils of German silver wire of different known resistances are arranged in such a manner that they may be connected, either singly or combined, in an electrical circuit. The

coils are all attached to the under side of a slab of ebonite, which forms the cover of the box. Upon this cover of ebonite, are

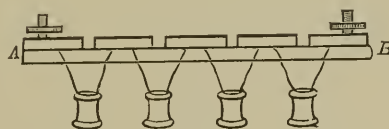


FIG. 11.

embedded a number of brass blocks to either end of which is connected one end of two adjoining coils, as shown in Fig. 11. If a current is passed from A to B, it has to traverse all the coils. The ends of the brass blocks are so arranged as to receive a plug which fits accurately the space between them. When a plug is put into an opening (a, Fig. 12), the current only passes through the plug, and not through the coil, so that by placing the



FIG. 12.

plug at a, the resistance from A to B is lessened by the amount of resistance of the coil of wire at a. The exact resistance of each coil is engraved on the lid near the plug hole. This furnishes a means of cutting out any number

of coils, or if out, of throwing them in without disturbing other connections. Thus a simple means of varying the resistance is obtained.

#### TO MEASURE RESISTANCE.

With a given battery force, notice the strength of the current as indicated by the milliamperes, which is obtained through the unknown resistance which it is desirable to measure. Replace this unknown resistance by known resistance; this is accomplished by adding coils from the resistance box until a current is reached according to the milliamperes meter, corresponding to that received in the first measurement. The sum of the resistances of the coils introduced will indicate in ohms the exact resistance of the unknown. For example: If I take in my hands one of the electrodes of a battery, and the milliamperes meter indicates a current of 20 ma., to ascertain the resistance of my body, from hand to hand, I simply attach the two poles of the battery to the binding posts of a resistance box and throw into the circuit sufficient resistance by withdrawing one at a time, the connecting plugs, to reduce the current to 20 ma. The sum of the value of the several coils thus thrown into the circuit, will indicate in ohms (disregarding the resistance of electrodes and connections) the resistance of my body from hand to hand. In the same simple manner, the electrical resistance of any portion of the human body may be ascertained, and it will be of practical interest later, to notice the great variation in resistance of its different parts.

#### GENERAL SUMMARY.

1. Resistance is the obstruction, met in any conductor, by a current of electricity.
2. No material is a perfect conductor; hence, all have resistance.

3. Materials of different quality have different resistance.

4. Increase the temperature of metals and their resistance increases.

5. Increase the temperature of liquids and many semi-solids, and their resistance is decreased.

6. Increase the density of a material conductor and its resistance is decreased.

7. Double the length of an uniform conductor and the resistance is doubled; *hence the resistance of an uniform conductor, of uniform sectional area, varies directly with its length.*

8. Double the sectional area of an uniform conductor and its resistance is lessened by half; *hence, the resistance of a conductor, of a given material and given length, varies inversely with its cross section.*

9. Resistance can be measured by comparing unknown resistances with resistance coils of known resistance.

## CHAPTER V.

### GALVANIC BATTERIES.

We have seen that the two elements of a battery must be of different electrical tendency or potential, in order to have a current pass between them.

#### POTENTIAL.

That there may be no mistake about the meaning of potential I shall refer, for a moment, to the old illustration of two reservoirs, one connected at the bottom with a hollow pipe, as represented in Fig. 13. Let reservoir B, represent the copper element,



FIG. 13.

represent the copper element, in a copper and zinc battery cell, and reservoir A, the zinc element. The height of the water level in B, represents the potential of the copper, while the water level in A, represents the potential, or in other words, the electrical level of the zinc. Now, as the reservoirs are connected at the bottom, the water will immediately seek to establish an equilibrium in the two reservoirs by flowing through the connection, in a direction from B to A. This is exactly what occurs between the copper and the zinc elements, the copper being of the higher potential, when the elements are connected a current of electricity flows from the copper to the zinc until they both possess the same potential.

#### MATERIALS OF WHICH ELEMENTS ARE MADE.

As it is necessary to have, for elements, substances

which possess considerable difference of potential, it is well to be acquainted with the electrical tendencies of different materials. Zinc is commonly employed as the positive pole of a battery, while copper, platinum or carbon are selected for the negative plate. The element most easily acted upon by the battery fluid forms the positive plate, and the one least easily acted upon the negative.

The following table called the *contact series*, and showing the relation of a few metals to each other, is valuable. Each metal in the list becomes positive when placed in contact with any one named below it. The farther they are separated, the greater will be the difference of their potential.

+ Zinc,	Silver,
Lead,	Gold,
Tin,	Platinum,
Iron,	- Carbon,
Copper.	

For example, if zinc and platinum are employed as the two elements of a battery, zinc will be +, and platinum -. Or if iron and carbon are used, iron will be +, and carbon -. Thus with all the metals in the list, the greatest potential exists between zinc and carbon, and any gradation may be obtained by combining intermediate metals.

#### ELECTROMOTIVE FORCE OF A BATTERY, OR VOLTAGE.

We have seen in the last chapter that the electromotive force of a current is determined by the difference in potential of the two ends of the connecting medium. To simplify the definition, it may be said to be the power of a current to overcome resistance.

To make a battery, then, of high electromotive force, according to our first definition, we must make the difference of potential of the two ends of our connecting medium, as great as is practicable. In a battery cell, the two ends of our connecting medium, are represented by the two ele-

ments. If then, we use elements whose potentials vary greatly, we will have a battery of high electromotive force, and if, on the other hand, the elements have a small difference of potential the battery will have a low electromotive force.

In sending a current of electricity through a compound substance, like the human body, it is supposed to break up into innumerable lines of force. If the current is propelled with very high electromotive force, the lines will remain close together, and pursue a more direct route through the resisting tissue. But if the electromotive force is not so great, the lines will become more widely separated in their endeavor to select tracks of the least resistance, and may fail altogether to return and complete the circuit. Hence: *The value of a current for therapeutic purposes, depends largely upon the electromotive force.*

#### ELECTROMOTIVE FORCE OF A BATTERY MAY BE INCREASED.

1. By increasing the difference of potential of its elements.
2. By increasing the active power of the battery fluid.
3. By increasing the number of cells in the circuit.
4. By keeping the battery fluid fresh, and the plates clean and properly amalgamated.

#### QUANTITY OR AMPERAGE.

A current may have a great electromotive force and still be of small quantity; it is, therefore, necessary for us to understand the distinction between these two terms. A current of great quantity may be generated which possesses very low electromotive force, just as a great quantity of water may flow through a pipe of large size, but possess very little force because the source is low. The quantity of water here is analogous to the quantity of electricity, the force of the water analogous to the electromotive force of the current. *The total amount of electricity pass-*

ing through a conductor in a given time, is designated the quantity.

#### QUANTITY IS INCREASED.

1. By increasing the size of the elements.
2. By bringing the plates closer together.
3. By exposing a larger portion of their surface to the action of the fluid.

#### RESISTANCE OF BATTERIES.

Resistance, as we have already seen, in electrical science, means the obstruction which a current of electricity meets with in its passage through any conductor. When a current passes from the carbon element of a battery cell, through any conductor, back to the zinc element, it meets and overcomes a certain amount of resistance. This is called the *external* or *non-essential* resistance.

#### INTERNAL RESISTANCE.

The current of electricity which is generated in any battery meets with a certain amount of obstruction, or resistance, in its own parts, such as the plates constituting the elements, the battery fluid and even the arrangement of the elements. This combined resistance of the interior of the battery is called its *internal* or *essential* resistance.

#### MEDICAL BATTERIES.

Batteries for medical purposes possess no peculiarities over many batteries used for generating electricity for use in the arts, and a few of the cells that I will notice are well known, and were first employed in the commercial world.

The **Smee** is one of the best known fluid combinations, and is called a constant battery because it possesses a means which prevents an accumulation of hydrogen on its positive

plate. The elements consist of zinc and platinum, and the exciting fluid diluted sulphuric acid. As pure platinum is ex-

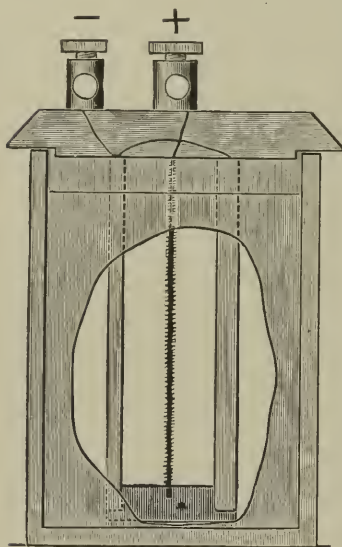


FIG. 14.

pensive, this cell is frequently constructed in a way to obviate excessive expense by using, instead of a pure platinum plate, a platinized silver plate. Silver, with a deposit of rough platinum in powder on its surface, is employed as represented in Fig. 14, as this plate thus platinized, produces a multitude of the hydrogen, it disengages itself more easily from its surface than from a smooth plate. In this cell, too, it will be noticed that the platinized plate is placed between the two zinc plates. This, also, is for economy. By this arrangement

we get action from both sides of the platinized silver plate and therefore double the active surface of the cell.

#### THE BICHROMATE OF POTASH CELL.

This cell is composed of elements of zinc and carbon, and the fluid is a solution of bichromate of potash in dilute sulphuric acid. The bichromate of potash prevents the hydrogen that is given off in the cell, from reaching the carbon plate.

#### THE GRENET BATTERY.

The Grenet battery as modified by McIntosh, is shown in Fig. 15. The elements consist of a single pair of zinc and carbon plates, and the fluid of bichromate of potash and dilute sulphuric acid. The cell is composed of a globular glass bottle (a) partially filled with the fluid.

Two plates of carbon (cc) reach from near the bottom of the bottle to the stopper in the top, where they are fixed to a piece of vulcanite which is attached to the elements in the McIntosh modification while in a soft state; this causing it to adhere so firmly to the connections that no creeping of fluids can take place. A zinc plate only half the length of the carbon plates, is fixed to a sliding rod, between the two carbon plates, in

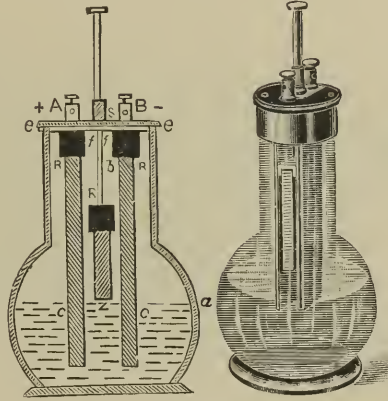


FIG. 15.

such a manner that the plates can be raised and lowered in the fluid. The above cell is used almost entirely for experimentation. It can be employed to run a faradic coil, and a few faradic batteries for medical purposes are constructed with this cell, or a slight modification of it, as the generating power.

For medical purposes, where portability is required, no form of battery is employed more than some modification of the Stohrer cell. It is like the Grenet battery, composed of zinc and carbon elements with an exciting fluid of bichromate of potash and dilute sulphuric acid. A very simple form of this battery is shown in Fig. 16. The elements of zinc and carbon in six pairs are represented in "A." The exciting fluid which receives the elements, is contained in the row of six small cups or cells shown in "B" of Fig. 16. These latter are composed of vulcanized rubber. This section containing the six cups also has attached to it an undivided half (D) which is for the purpose of furnishing a drip cup for the elements when they are not in use.

The element portion of the battery (A) is composed of a polished hard rubber base, lined with soft rubber which

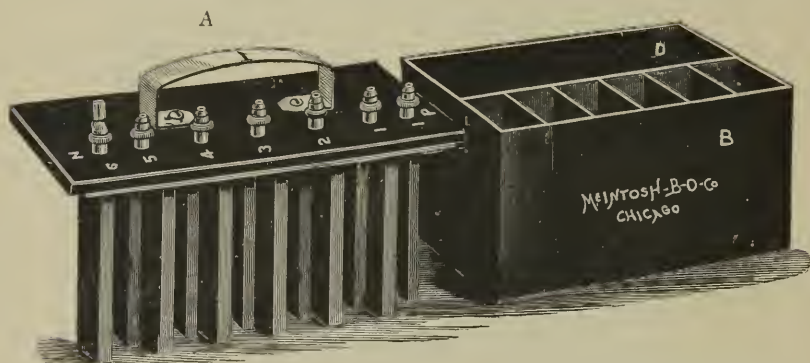


FIG. 16.

serves the purpose of a hydrostat. The elements are fastened to metal bridges, and are then attached to the base by the screws which terminate in binding posts. They are arranged so that post (P) is connected with a single carbon and post (N) with a single zinc; the remaining posts are each connected with a pair of elements.

When the above elements are immersed in the fluid, the carbon element assumes a higher potential than the zinc, and the current will therefore leave the cell at the carbon element, and if in circuit, will return to the cell by the zinc element. If the six cells shown in "A," Fig. 16, are in circuit, the post to which the last zinc in the series is attached, forms the negative pole, while the last carbon element in the series remains the positive pole. The current in external circuit of course traverse a direction from the positive pole of the battery to the negative.

Batteries constructed on some modification of the above plan, arranged in compact boxes for portable purposes, are numerous, and later we will notice those more at length that seem most worthy of our attention.

## TWO FLUID CELLS.

Two fluid cells are constructed for the purpose of preventing hydrogen compounds gathering at the zinc plates and retarding the action of the cell. The two principal types are Grove's and Daniells' cells. The Grove's cell is used when a very powerful current is required for a few hours, while the Daniells' cell is used where a constant current of moderate strength is required for days, weeks or months.

## GROVE CELL.

The metals used are zinc and platinum, the fluids strong nitric acid, and dilute sulphuric acid. A small cell of porous earthenware is filled with the nitric acid and contains the platinum element. This cell is set into a larger cell, a considerable space remaining between it and the inner surface of the external larger cell. The outside cell is usually constructed of ebonite, and into it is put the dilute sulphuric acid and the zinc element. The porous inner cell when wet, allows the electricity to pass through it, while it does not permit the two fluids mixing.

In this cell the hydrogen, which, wherever it is set free, must be formed in the sulphuric acid, would have to travel through the nitric acid in order to reach the platinum. Even if it is only liberated at the platinum plate, it is still in contact with nitric acid, and the nitric acid and the hydrogen will at once combine to form nitrous acid and water, both of which will remain in solution in the free acid.

## BUNSEN CELL.

Bunsen cell is a two fluid battery that is similar to the Grove in construction, except that the plate immersed in the nitric acid, is carbon instead of platinum. This cell is not so powerful as the Grove.

## DANIELLS' CELL.

This cell, one of the first devised for improvement over the one fluid battery, is also the most successful attempt to obtain constancy. Zinc and copper are the metals used in this cell for elements. The zinc is usually immersed in a dilute solution of sulphuric acid, and the copper in a saturated solution of sulphate of copper.

A good idea of the principle of this cell, can be gained by reference to Fig. 17. Zinc in the form of a rod is

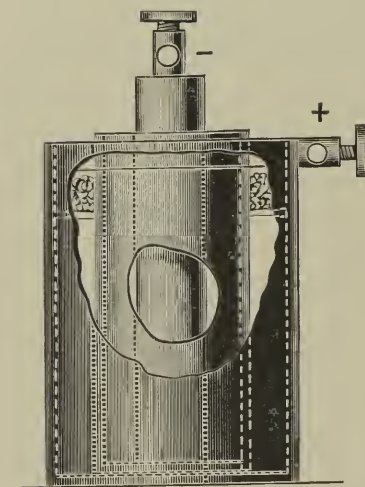


FIG. 17.

placed in the porous cup, and according to the battery required, the cup, is filled with either dilute sulphuric acid, salt and water, or plain water. The weaker the fluid is, the greater constancy will the cell possess, while its power will be considerably decreased. Inside the copper outside cell, near its top, is a perforated copper shelf. This shelf serves the double purpose of keeping the porous cell in place, and of holding a number of crys-

tals of sulphate of copper. This cell, after the porous cell is in place, is filled with a saturated solution of sulphate of copper.

When the circuit is closed with this cell, the hydrogen, whether it comes from the zinc through the porous cell towards the copper, or is liberated on the copper, comes in contact with the solution of sulphate of copper, and taking from it an atom of sulphur and four atoms of oxygen, sulphuric acid is formed and metallic copper is liberated and deposited on the copper plate. Sulphate of zinc is formed

in the sulphuric acid cell by the action of the acid on the zinc.

This cell, while it is one of the most constant yet constructed, is by no means absolutely so, because, as the zinc dissolves, the solution belonging to it becomes less active and less conducting.

Of the many different devices that have been adopted to make the Daniells' cell what its inventor sought to make it, viz., an absolutely constant cell, and of the many failures attending these efforts, I must refer the reader to other works on electricity.

#### THE LECLANCHE CELL.

This cell, Fig. 18, has become popularized of late in the medical world, because of being the cell used and

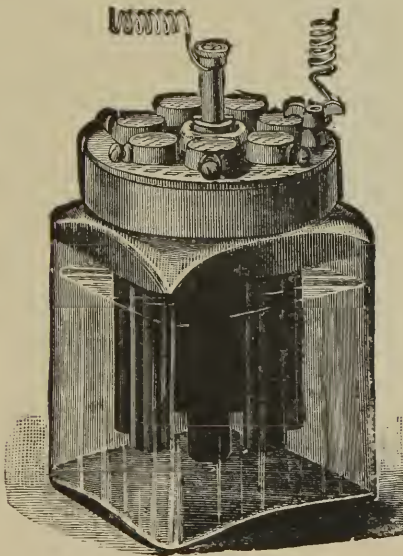


FIG. 19.



GENUINE GONDA POROUS CUP AND ZINC.

FIG. 18.

recommended by Dr. Apostoli, of Paris, who has accomplished so much to put electro therapeutics on a legitimate and scientific basis. The Leclanche cell has been well

known for some time and extensively used for electric bells, telegraph and telephone purposes. The cell consists of zinc and carbon elements separated by a porous cell. The zinc is surrounded with a solution of hydro-chlorate of ammonia, and the carbon with a mixture of powdered charcoal and binoxide of manganese. The porous cell containing the mixture of charcoal and manganese is filled with water.

The Leclanche cell has moderate force, and when used in series of about fifty, and allowed to do discontinuous

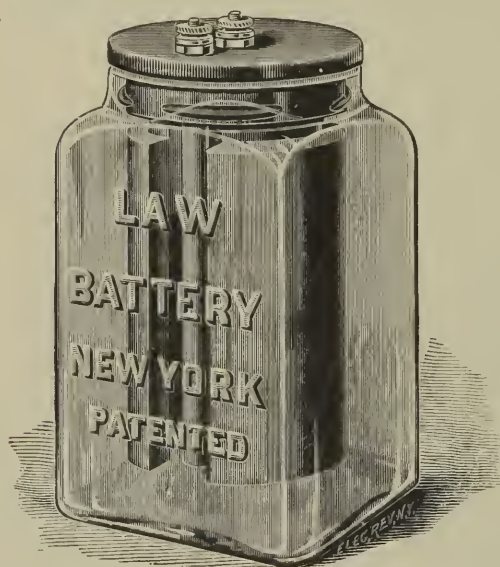


FIG. 20.—LAW CELL.

work makes a valuable medical battery which will remain in action a long time with no other attention than filling occasionally the cells with water. A serious objection to the Leclanche battery for medical purposes, is the tendencies of the fluids to creep over the edges of the jar, thus making it uncleanly

for an office. The fluids, also, in creeping up the binding posts occasionally insulate the connections and destroy, temporarily, the circuit of the battery.

#### DIAMOND CARBON BATTERY.

The cell shown in Fig. 19, called by its manufacturers the Diamond Carbon cell, is one of the most satisfactory for an office battery that I am acquainted with. The elements are carbon and zinc, with a large exposure of carbon

obtained by using several carbon sticks about three quarters of an inch in diameter, for the negative element, instead of employing but one. These are arranged in a circle around a small zinc rod which perforates the lid in the center. The exciting fluid is hydrochlorate of ammonia in water. The cells are closed securely so that evaporation is very slow, and creeping of fluids never occurs. For every day office use, they will work without recharging from one and a half to two years.

## CHAPTER VI.

### SELECTION OF CURRENTS.

In selecting galvanic batteries for different purposes, we must constantly bear in mind Ohms law, or we will find many things to perplex. We must remember that the tissues of the body possess widely varying degrees of resistance, and that we must select our batteries with that object in view if we are not to be disappointed in our results. It would be a great mistake to prepare a battery of a few very large cells for the purpose of applying galvanism through tissues of considerable resistance, as when two electrodes are placed upon the surface of the body quite widely separated. Equally absurd would be the selection of a battery composed of a large number of small cells, arranged in series, for the purpose of heating a platinum wire, of very small resistance, for cautery purposes. If, however, we reverse the conditions and employ the large number of small cells where we have resistance to overcome, and the few large cells where quantity is desired for heating purposes, with little resistance, little difficulty will be experienced.

We arrange our batteries then, in medicine, with two objects in view: first, for currents of high electromotive force and small amperage, and second, for small electromotive force and large amperage. The first is employed in applying the galvanic current to all portions of the body by means of separated electrodes, making the tissues part of the circuit, while the second is employed for cautery purposes when the circuit between the two poles is

completed by means of a platinum wire or knife which becomes heated by the passage of the large current. While we recognize that the difference in the above currents depends entirely upon the size, number and arrangement of the same kind of cells, and that each are but different expressions of the same force, I shall speak in this work, for the sake of a convenient distinction, of the one, as the galvanic current or current of tension, and of the other as the cautery current or current of quantity; the former being the one of high electromotive force and small current, and the latter of small electromotive force and large current.

#### GALVANIC CURRENT.

**The galvanic current** for all medical purposes, should be one generated with an electromotive force that can be raised from one to one hundred volts, and with a possible amperage of two thousand milliamperes or two amperes. Of course, it is not expected that it will be necessary to employ a current of one ampere through the tissues of the body; neither will the above battery give that current when additional resistance, represented by a portion of the body, is placed in the circuit.

The above is simply the possibilities that a generator should possess when all resistance is withdrawn from its external circuit.

#### CAUTERY CURRENT.

The cautery current for medical purposes should possess an electromotive force of not more than four volts, while its amperage should reach as high as forty amperes.

#### ARRANGEMENT OF CELLS.

**Compound Circuit.** If we desire a battery possessing high electromotive force and comparatively small quantity, we arrange the cells in "series." This is accomplished by attaching the negative element of each cell with the positive element of the next one in line and so on; for

instance, in an ordinary zinc and carbon battery we attach the carbon element of one cell with the zinc element of the next one until all the cells of the battery have been united in like manner. When cells are arranged in this way, each cell reinforces the electromotive force of its neighbor by its own until, when we reach the end of the series, we have a battery with an electromotive force of as many volts as the product of the number of cells in line multiplied by the electromotive force of one of its cells. For example: If we have a battery of twenty-four cells arranged in series, and each cell has a voltage of one, the electromotive force of the battery is twenty-four volts. The above arrangement is called a compound circuit.

In arranging a galvanic battery, then, for a current of intensity, its cells should be of moderate size and strength, and arranged in compound circuit. To construct a battery with an electromotive force of one hundred volts, with moderate quantity, it would be necessary to arrange a large number of cells in line. A battery for medical purposes, of the above strength, is ordinarily constructed as a stationary and permanent apparatus, and for that reason is constructed with one of the more permanent cells, as some modification of the gravity cell, the Leclanche, the Law or the Diamond Carbon. The author prefers one of the latter, the improved Diamond Carbon being the cell now in use by him. The maximum electromotive force of the gravity cell is about one volt. Therefore, one hundred of these cells would be required to construct a one hundred volt battery. But the gravity cell has lost favor with the therapist since the strong currents have been employed; first, because they are not easy to care for; second, because of their uncleanness, and third, because of their high internal resistance which constantly increases with age, and finally renders the battery useless.

The electromotive force of the Leclanche, the Law and the Diamond carbon cell, is about the same in each, viz.,

1.5 volts. A battery of one hundred volts of these cells, therefore, would require but sixty-six cells. The author employs for an office battery fifty Diamond Carbon cells in compound circuit, and it has proved most satisfactory for all kinds of work requiring a circuit of intensity. Such a battery will give a maximum of one and three-fourths amperes with an electromotive force of seventy-five volts.

For portable batteries, the ordinary zinc and carbon cells with an exciting fluid of dilute sulphuric acid and bichromate of potash give the best satisfaction. The



FIG. 21.

McIntosh battery of this description (Fig. 21) employed by the author, has a maximum electromotive force of nearly two volts to a cell. The chloride of silver battery is very convenient when a current of moderate strength only is required. They are unreliable, however.

TO ARRANGE CELLS FOR QUANTITY.

For cautery purposes, we have said that a current of four volts electromotive force and a quantity of forty

amperes was required. To couple cells for quantity, we arrange them in what is called simple circuit. This is accomplished by attaching all the carbon plates of the battery, or those of like potential, on one side, and the zinc plates, or those of opposite potential on the other. In this way the electromotive force of the whole battery remains the same as one cell, and the quantity is proportionate to the combined element surface immersed in the battery fluid.

While cells must be coupled as stated above for quantity, the same effect can be accomplished by simply increasing the size of the cells (see page 49). It is much more convenient to couple two large cells with large surface exposure which will generate twenty amperes each, than forty smaller ones which will generate but one ampere each, and for that reason large cells are almost invariably employed for cautery batteries.

As the voltage of large cells is the same as that of small ones, of the same construction, it will be necessary to couple two or three in compound circuit, in order to get for the battery the necessary electromotive force of four volts.

The different forms of batteries and apparatus for cautery work, will be described in the chapter on cautery batteries.

#### SUMMARY.

1. Medical batteries are arranged (a) for intensity, and (b) for quantity.

2. A medical battery arranged for intensity, should possess a maximum electromotive force of one hundred volts, and a maximum amperage of not more than two amperes.

3. A medical battery arranged for cautery should possess an electromotive force of not more than four volts, and the maximum quantity should be forty amperes.

4. A medical battery of intensity should be of small cells arranged in compound circuit.

5. A medical battery for cautery purposes may be of small cells arranged in simple circuit, or of two or more very large cells.

## CHAPTER VII.

### GALVANIC CURRENT GENERATED BY MECHANICAL ENERGY.

Until very recently, no mention in medical literature could be found of any other means of generating the continuous galvanic current than by means of the chemical battery. The rapid developments, in the commercial world, of economic devices for the generation of electricity, for all purposes, has led the physician to look to his laurels, and he has already found means by which the electric light wires which pass his window, can be tapped with safety and utilized for therapeutic purposes, and, finally, he has constructed a dynamo which can be employed exclusively and economically in the place of the more ancient battery.

#### THE DYNAMO.

Electricity can be generated by a proper motion being imparted, by means of any mechanical energy, to a magneto-electric system. Such a system consists of a magnet, a wire helix and an armature. The cut, Fig. 22, represents one form of a magneto-electric system. A, is a horseshoe magnet. B, the keeper or armature surrounded by a helix of wire. The armature by induction has become magnetized. The end of the armature opposite the positive arm of the horse shoe is negatively magnetized, while the other end is positively magnetized. In like manner the wire helix is influenced by the lines of force surrounding the magnet, and any movement imparted to either the mag-

net or armature will be followed by a change of potential in the ends of the wire, and the terminals, D, will attract each other, or if they already touch, a current of electricity will pass.

**The Magnetic Field** of a magneto-electric generator, is the space surrounding the poles which possesses magnetic lines of force, and as it is desirable to have these lines of force concentrated, and the fluid as dense as possible, the field magnets are made for economy with their poles facing each other.

When the essential parts of a magneto-electric machine are at rest, there is no electrical disturbance. It is only where movement is imparted to one or more of the essential parts that electricity appears. While all magneto-electric machines possess the essentials presented above, there are many modifications of these, and we can give but the merest outline of the development of these wonderful devices.

When the permanent magnet is employed in the construction of these machines, they are called simply the "magneto-electric machine." When an electro magnet is employed, it is called a "dynamo-electric machine." A current of electricity is necessary to maintain the magnet of the latter machine. This can be furnished by a battery, a separate machine of the same kind, a part of the machine itself, or by having a part of its own electricity traverse its own coils.

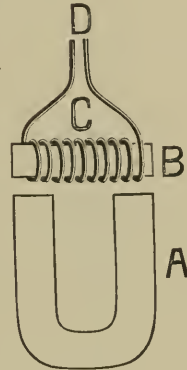


FIG. 22.

#### ARMATURES.

It has been seen that movement of but one part of the three essential parts of the magneto-electric system is necessary to produce electricity. For the sake of economy then, the armature on account of its smallness compared to

the magnet, is the part of the system to which the motion is usually imparted. There are three principles of thus utilizing the magnetic fields.

1. The form ordinarily employed in the old style of the medical magneto-machine is shown in Fig. 23. This

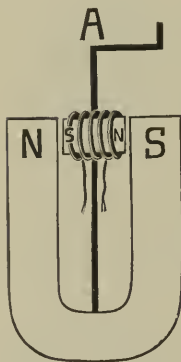


FIG. 23.

is one of the simplest and most primitive forms of the magnetic machine. N and S represent the poles of an ordinary horseshoe magnet, which is called the field magnet; and (N) and (S) the two ends of the keeper of the horseshoe magnet, or the armature surrounded with a coil and transfixed with an axis (A) for rotation. This armature depends upon the adjacent magnet for its polarity, and is always opposite in polarity to the arm of the magnet with which it is in closest contact. When the armature is rotated so that its opposite ends are equal distance from each pole of the magnet, that is one quarter revolution, the polarity of the armature will be at its minimum, in fact will have no polarity because of being equally attracted by each pole. When a half revolution of the armature has taken place, (S) will be brought in the vacuity of (S), and will, in consequence, change to the opposite polarity or (N). Thus, with every half revolution of the armature, its polarity is completely changed, and as its polarity changes, an electromotive force is set up in the surrounding coil. If the terminals of these wires are attached to a commutator, the current of electricity generated can be conducted away by means of appropriate wires.

If a galvanometer is placed in the circuit of these wires, the presence of electricity can be recognized as soon as the crank of the machine is turned.

Fig. 24 represents the Siemens armature. (N) and (S) are the field magnets, (N) and (S) the armature within and mounted so as to rotate on a longitudinal axis. This,

like the other, is inductively magnetized, and as the armature is rotated before the field magnets, its polarity is constantly changing and in consequence, a to and fro current is generated in the coils of wire, and by means of commutators it is conducted away through appropriate conductors.

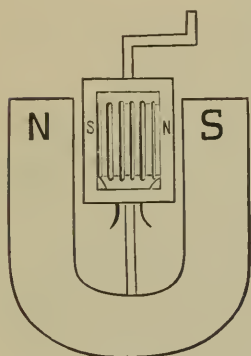


FIG. 24.

3. Fig. 25 represents the third form or what is called the gramme ring. As represented in the cut, a large hollow ring is rotated between the two powerful arms of a field magnet. The ring is inductively magnetized. The outer margin of the ring at (S) while containing (N) polarity, contains (S)

polarity at its inner margin. As the armature is revolved and the margin of the ring is constantly changing its polarity in consequence of coming alternately in the vicinity of the (S) and the (N) pole, a powerful electromotive force is imparted to the coils of wire surrounding the margin of the ring and a current of electricity is generated.

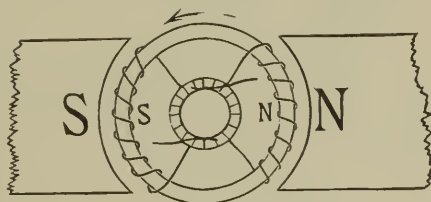


FIG. 25.

In practice several separate coils of wire are fixed in the ring. This peculiar form of machine is called the Gramme machine and has a great many modifications, and in connection with the other two forms outlined above, is capable of many combinations.

#### THE SPERRY MEDICAL DYNAMO.

The first real serious attempt to construct a comprehensive medical and surgical dynamo, reached its consum-

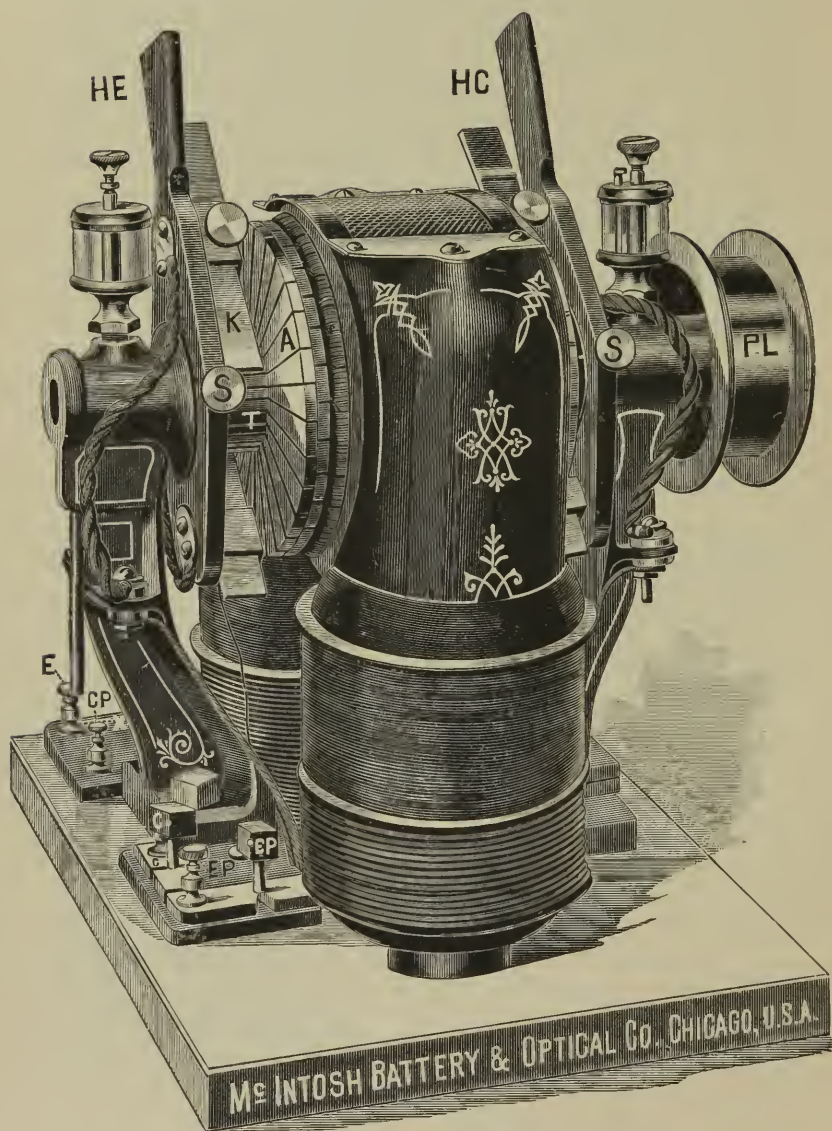


FIG. 26.

mation in the Sperry Medical Dynamo, Fig. 26. The author of this work, in experimenting with batteries, medical and surgical, realized their deficiencies in many points, especially when a continuous and a large amount of work was required of them. In seeking for a way out of the difficulties, the dynamo naturally suggested itself. Here again was found, as with the battery, that two distinct machines would be required, one for cautery work and one for physiological work. These difficulties were submitted to a number of practical electricians, and until Mr. Sperry was consulted, without results. Mr. Sperry stated that one machine could be constructed that would combine all the advantages of the best cautery batteries, which gave a current of large amperage and small electromotive force, and of the series batteries which give a current of small amperage and high electromotive force. In other words, two distinct machines in one small dynamo. Mr. Sperry, therefore, was induced to carry out his ideas, and the result has more than realized our expectations.

The dynamo, Fig. 26, is a modification of the Gramme machine. Between the two arms of the field magnet, revolves the ring armature with two distinct windings of wire, each terminating in its respective commutator on opposite ends of the armature. The two windings are distinctly different. One is of small wire of great length which generates a small current of great electromotive force, and the other is of large short wire which generates a large current of small electromotive force. The first current is used for physiological and electrolytic work, while the latter is used for cautery purposes. From the commutators the respective currents are collected by the brushes KK, and carried to their appropriate binding posts. By means of the brushes the current is controlled in strength. When the brushes, by means of the levers H E and H C are brought opposite the poles of the magnet on the commutator, the current reaches its maxi-

mum strength; when on the other hand, the brush is brought to a point half way between the poles of the magnet, a neutral point will be found (because of the equal attraction of both magnets) at which place there is no current. By moving, then, the brushes between these two points on the commutator, the current can be modified in strength at will, without disturbing the velocity of the machine.

## CHAPTER VIII.

### INDUCED OR FARADIC CURRENT.

The simplest method of producing the induced current, is to pass a galvanic current through one of two parallel wires placed on an insulated plane, when a current will instantly pass in the opposite direction through the second wire. This second current is the induced current, and is only noticeable at the beginning and ending of the flow of the primary current, and in an opposite direction to it at the making, while at the breaking, it flows in the same direction.

In order to increase the strength of an induced current, it is necessary to increase the length of the wires. This is accomplished by coiling them over each other on a bobbin after covering them with silk or some other non-conductor for the purpose of insulation. Thus, while remaining practically parallel, wires of great length may occupy a comparatively small space.

The power of the induced current is found to be greatly augmented by placing a core of soft iron wire in the center of the coil. This is because the iron becomes magnetized, as a result of the current passing in the coil surrounding it, and the magnetism of the core in turn, greatly reinforces the inductive power of the primary current.

Now, it must be remembered that the induced current is only perceptible at the instant of beginning and ending of the primary current. It is therefore necessary, in order to increase the number of induced shocks, to cause rapid interruptions of the current in the primary coil. Syste-

matic interruptions are accomplished by means of an automatic device known as Nief's hammer.

The essential parts of a faradic battery may be enumerated as follows:

1. A primary source of power.
2. A primary coil of coarse insulated wire.
3. A secondary coil of wire surrounding or covering the primary coil.
4. A core of soft iron over which the coils are wound.
5. A graduater which consists of a non-magnetic tube sliding loosely over the soft iron core in a space left between it and the primary coil.
6. An interrupter or rheotome.

The source of power of a medical faradic battery, is usually some form of the Grenet cell (Fig. 15), or other form of the zinc and carbon battery. One or more cells may be employed—usually one.

The primary coil is usually made of larger wire than that employed for the secondary coil, and it may be much shorter. This wire should

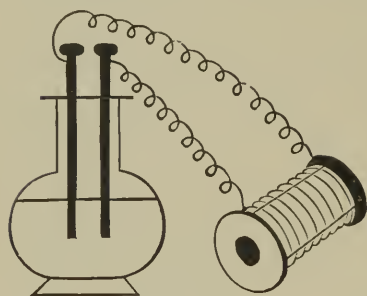


FIG. 27.

be covered with cotton or silk in order to insulate its different coils from each other and also from the secondary coil. This wire is then coiled over a bobbin in the hollow of which is placed a bundle of soft iron wire (Fig. 27). The two term-

inals of this wire are connected with the opposite poles of the source of power and the primary coil is complete.

The secondary coil is usually constructed of much finer wire than that of the primary coil. This insures larger surface for induction and therefore a current of greater intensity. This wire, also insulated like the first, is wound over the primary coil until the required length

has been obtained and its terminals attached to binding posts to which electrodes may be connected.

Fig. 28 represents the secondary coil wound upon the primary and terminating in binding posts. We have already referred to the hollow of the primary coil being filled with soft iron wires. The end of this iron can be seen protruding from the coil in Fig. 28. As the current passes through the primary wire covering this iron core, it makes a strong, temporary magnet of it. In this state of temporary magnetism, it, of course, attracts steel, iron filings and other forms of metal like a permanent magnet. This fact is utilized in a faradic battery in making the automatic interrupter to the primary current.

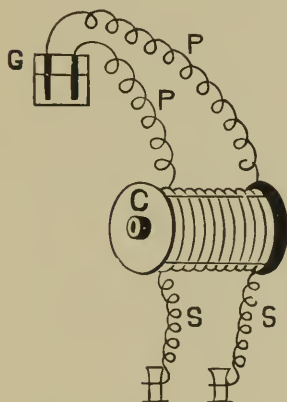


FIG. 28.

**The Automatic Interrupter or Rheotome** is an absolute necessity in every faradic machine. An induced current only occurs in the secondary coil at the instant the current in the primary coil begins and stops. In order, then, to get the greatest effect of the induced current, it is necessary to provide for some method of rapidly interrupting the primary current. This is accomplished, ordinarily, by means of some modification of Nief's hammer. Fig. 29 represents the primary coil with its interrupter in

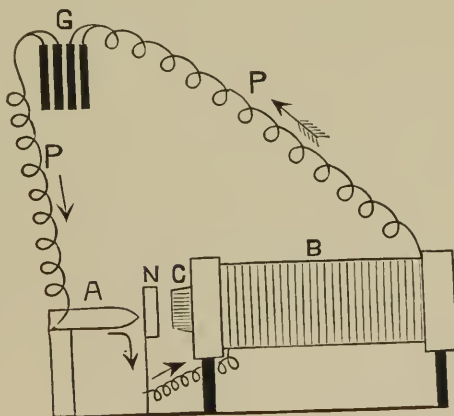


FIG. 29.

profile. The current starts from the battery cell (G), passes over the wire as indicated by the arrow, to a point of steel (A), resting against a steel spring (N), through this spring it passes and escapes from it at its lower end, by means of a wire, to the primary coil (B); it traverses this coil and completes its circuit by returning by (P) to the battery (G). At the instant this circuit is completed, however, the core of soft iron (C), over which the wire is coiled, becomes temporarily magnetized and by virtue of this magnetism, attracts the spring (N) to itself, and breaks the contact between (N) and the steel point (A). Thus instantly, the circuit of the primary coil is broken, and as its current ceases to flow, instantly the core of soft iron which depends upon this current for its magnetism, becomes demagnetized and the spring (N) flies back to again complete the circuit of the primary coil. By means of this principle, modified in many ingenious ways, almost as many or few interruptions per minute may be obtained as are desired.

At each interruption of the primary current, a current of greater intensity is induced in the secondary coil both at the stopping and beginning of the flow. We remember that the induced current produced at the beginning of the primary, flows in the opposite direction to the latter, and in the same direction when it stops. Thus we find the induced current, unlike the primary, flowing alternately in both directions. The part of the current, however, that is induced at the breaking of the primary is stronger than the part that is induced at its commencement, and, therefore, while the induced current in reality flows both ways, the part of greatest intensity takes a direction corresponding to that of the primary current.

An induced current in turn, has the power to induce a third current in a third wire, and sometimes a third and even a fourth or fifth is added to an induction machine, each with its separate terminals and different intensities.

When there is no extra coil for the induced or secondary current to act upon, it reacts upon the primary coil reinforcing its action. This is called the extra current.

The strength of the induced current may be easily varied by cutting off the influence of the soft iron core by sliding a non-magnetic cylinder of metal over it so as to separate it from the primary coil. This cylinder is almost universally employed as a graduater of the strength of the current in the faradic machine. When the cylinder completely covers the core, the current is comparatively weak, and any gradations from this to the maximum current may be obtained by drawing out the cylinder.

In some batteries, also, the coils are so constructed that the primary and secondary coils slide over each other; thereby rendering it possible to make a very delicate adjustment of the two currents.

#### MEDICAL FARADIC BATTERIES.

A faradic battery for medical purposes must possess certain distinctive features to make it practical. Besides the source of power, the battery cell, the primary and secondary circuit with their coils, and a simple interrupter, it is necessary to have two sets of binding posts, one for the primary current and one for the secondary, to which the conducting cords leading to the electrodes may be attached. It is necessary, also, to have a pole changer, a device by which the direction of the primary current may be changed at will. Besides an ordinary rapid interrupter, it is often desirable to have some means by which slow interruptions may be maintained. Different inventors accomplish this by different ingenious devices.

Medical batteries are made both for portable and stationary work. In portable batteries it is necessary that the fluids in the cells be prevented from spilling when carried from place to place in a physician's carriage or buggy. Stationary battery plates are ordinarily attached

to a table and the cells are connected from a distance by means of a cable of wire. The machine shown in Fig. (30) is a very convenient form of faradic battery for a portable or visiting instrument. It has a large rubber cell or drip cup composed of hard vulcanized rubber, in which the elements can rest after having been withdrawn from the cell. The coil, rheotome, binding posts, pole changer indicator, and switch to connect primary or secondary current with the binding posts, are attached to a polished hard rubber plate 5x7 inches. Under the plate is a space for

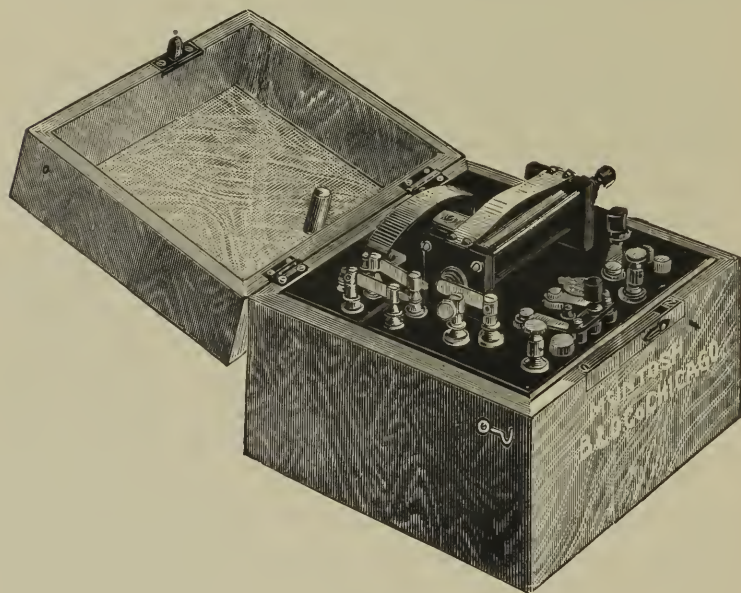


FIG. 30.

the electrodes. The pole changer in this battery is so arranged that when moved to the left or right, the uncovered button indicates to which pole the binding post of that side belongs. It is not necessary to change the conducting cords to a new set of binding posts when it is desirable to change the current from primary to secondary, or the reverse, as this is accomplished by means of a switch.

After using this battery, it is only necessary to lift the elements out of the fluid into the drip cup and close the lid of the battery box to make the cells completely hydrostatic.

THE TRIPIER INDUCTION APPARATUS AS MODIFIED BY  
MCINTOSH.

This instrument, Fig. (31) adopted by the author, is one of the most perfect faradic machines manufactured in this country, and with a simple rheostat for controlling the primary current, it meets all the requirements of the gynecologist.

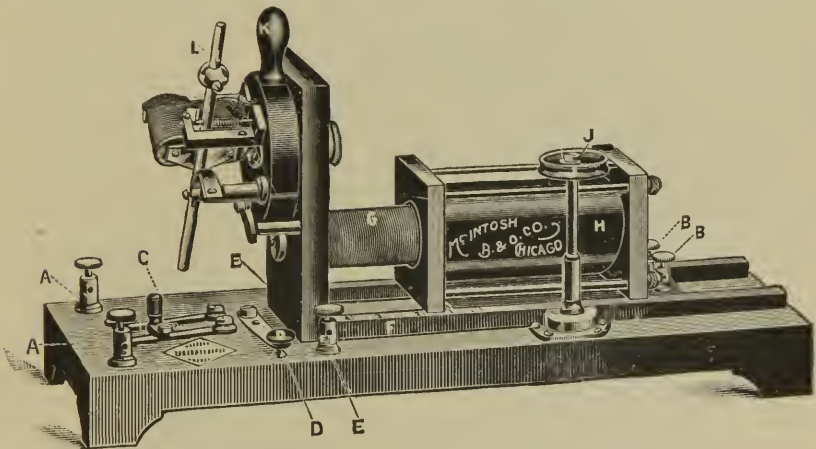


FIG. 31.

This apparatus is furnished with three coils of different thickness and length of wire; one of which (H) is shown in the cut. AA, are the binding posts to which the cells or battery is attached. BB, the posts to which the cords going to the patient are attached. C, the pole changer or commutator. D, contact button, which, when pressed, stops the current. EE, posts for taking the current from the primary coil. F, graduated scale. G, primary coil. J, rack and pinion for sliding the secondary coil backward and forward over the primary. The more the primary coil is covered by the secondary, the more

intense will be the current. K, handle by which to increase or decrease the number of interruptions made by the bar L. By moving the handle, K, *from* the operator the interruptions are *slower*, and *vice versa*, permitting a variation of from 50 to 3,000 interruptions per minute, the latter being used principally for allaying pain.

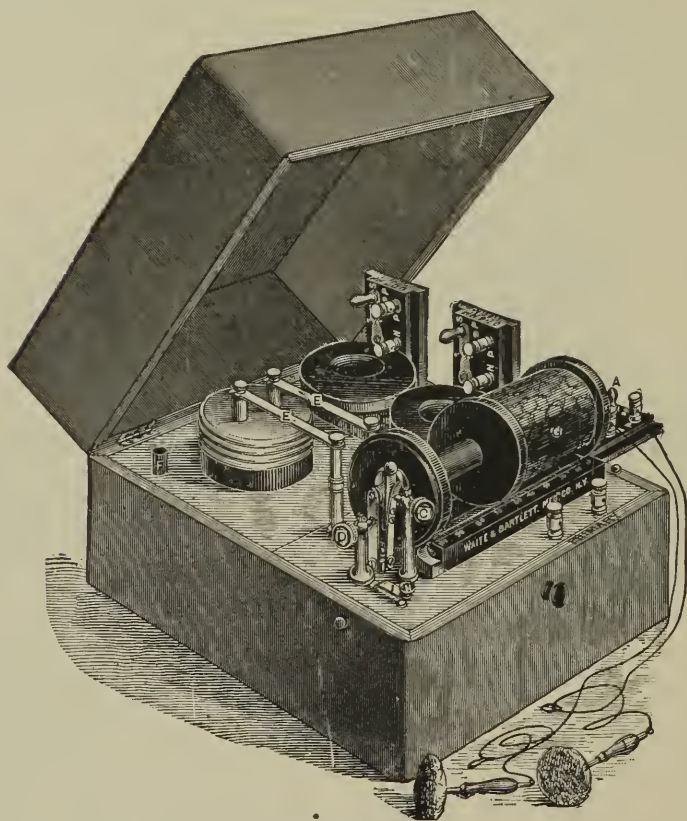


FIG. 32.—ENGLEMAN BATTERY.

This apparatus is peculiarly adapted to the operation of general faradization by the bipolar method, and can be operated by a reduced street wire current, a couple of Leclanche or Diamond Carbon cells, or a small storage battery.

## THE SAMPLE FARADIC BATTERY.

Fig. 33 represents a very complete battery for gynecological work. It has both a coarse and fine wire coil, the former with a slow interrupter, the latter with a fine interrupter or trembler. The secondary coils are immovable in this apparatus, each having its own primary coil, thereby insuring complete saturation of the secondary. This is a point of considerable importance. The current is regulated in strength by a coil rheostat which is a part of the instrument, or by means of any of the standard current controllers. The instrument is complete in every respect, and can be relied upon to meet all indications of the modern faradic machine.

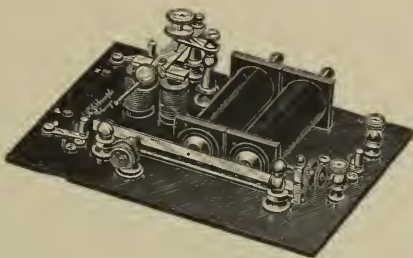


FIG. 33.—THE SAMPLE BATTERY.

## CHAPTER IX.

### STORAGE BATTERY.

The so-called storage batteries are not, strictly speaking, *storage* batteries. That is, electricity is not stored in any form of a cell without affecting the integrity of the cell, as water or gas may be stored in a tank or reservoir. The nearest approach to a strict storage of electricity, is that phenomena observed in the charging of the Leyden jar with static electricity.

The storage battery or accumulator which practically, if not actually, stores the galvanic current, does so by peculiar chemical changes which are produced in the cells when a current is passed through them, the reversal of which chemical change, when the charging current is withdrawn, reproduces a current similar to that of the charging current. Thus, so-called storage of electricity occurs, to a degree, when the ordinary battery cell becomes polarized. Upon the basis of this phenomena Grove, in 1842, constructed a gas battery.

#### PLANTÉ'S STORAGE CELL.

In 1842 a Frenchman, Gaston Planté, constructed the first practical storage cell, "using as electrodes, two large sheets of lead rolled together and electrically insulated from each other with strips of *gutta percha*, as shown in Fig. 34. The method of rolling is shown at (A), and the sheet rolled and clamped at (B), projecting strips of lead being left attached to each for terminals. They were then immersed in water acidulated with ten per cent sul-

phuric acid in a tall glass jar, and subjected to the action of a battery current supplied by two or more cells. A portion of the water being decomposed, the oxygen evolved at the anode combined with the lead, forming a dioxide, and the hydrogen was occluded on the cathode."<sup>1</sup> "When the anode ceased to absorb oxygen, as indicated by the escape of the gas, the cell was disconnected from the battery and discharged by making an external connection between the terminals and the electrodes, and then recharged with a reversed current."

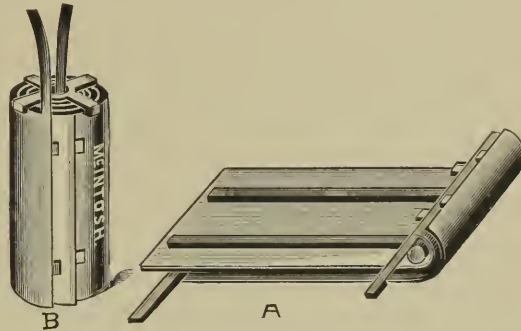


FIG. 34.

In like manner the cell was charged and discharged repeatedly, its capacity increasing as the dioxide of lead on one electrode increased and the spongy condition of the opposite electrode proportionately developed.

The electromotive force of the Planté cell is about 2.54 volts.

#### FAURE CELL.

The time and waste required to prepare the Planté cell, naturally led, in time, to a means of artificially preparing the plates. This was first practically accomplished in 1880, by Camille A. Faure. On the surfaces of lead plates was spread a paste composed of red lead and sulphuric acid which at first was confined to the plate by placing sheets of paper and felt between them for the double purpose of keeping the coating in place and for insulation.

<sup>1</sup>Atkinson's Dynamic Electricity.

They were then rolled together something after the fashion in the Planté cell, and after being subjected to electrolysis for the purpose of changing the *minium* or red lead to dioxide of lead and spongy lead the cell was ready for use.

It was found that the coating on the smooth plates detached easily, that the felt prevented perfect electrolysis, it soon became corroded and ceased to insulate, the coating and felt becoming detached fell to the bottom of the cells, the cells became short circuited, and otherwise interfered with the action of the battery. As a result, it was improved by employing plates with holes in which the paste could be securely held. These perforated plates, called "grids," are prepared by filling the crevices with paste made of *minium* and sulphuric acid, for the positive plates and lethane and sulphuric acid for the negative. The plates are insulated with hard rubber forks. They may be placed in glass cells for stationary work or hard rubber where portability is desirable.

The electromotive force of the improved Faure cell is two volts and its internal resistance but .001 to .005 ohms. It gives 30 amperes for 11 hours. This is the 15 plate stationary cell. (Atkinson.)

Minor improvements in the storage battery are constantly announced, having for their object economy of construction, portability, durability and maximum return of energy. The principles in all, however, are practically the same.

#### STORAGE BATTERY FOR MEDICAL USE.

It has been seen in the necessarily short description of the storage battery, that the essentials of a storage cell are a containing jar, a solution of dilute sulphuric acid called the *electrolyte*, a series of lead plates called the *pile*, and a means of insulating and separating the plates. The negative and positive plates which are previously prepared, differ in appearance when new; the positive plate being a light brown while the negative plate is of a grayish hue.

Storage cells as now ordinarily constructed, are more suitable for galvano cautery work in gynecology, than as a substitute for the ordinary galvanic battery. The latter, for gynecology or for medical purposes generally, should have a high voltage compared to its amperage, from 30 to 60 volts, with from 1 to 2 amperes on short circuit, while for cautery purposes (see page 83) the reverse is required, or a small voltage with a large amperage, 2 to 4 volts with

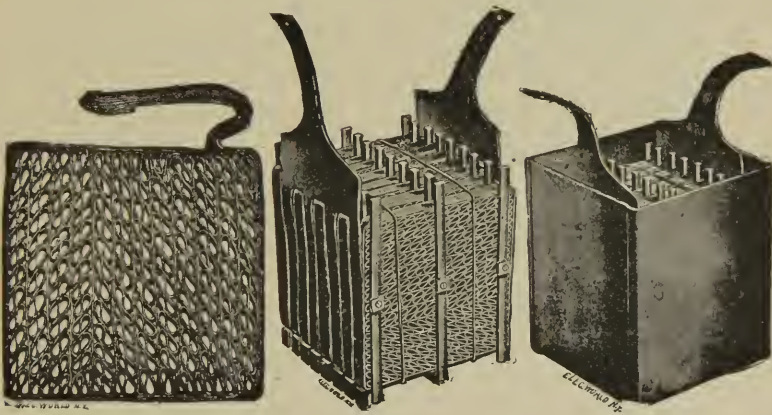


FIG. 35.

from 20 to 40 amperes on short circuit. It can readily be seen, then, that the storage battery with an electromotive force of two to four volts and a current of 20 to 40 amperes, is suitable for a cautery current alone. The compactness, cleanliness, and portability of the storage cell lend to it additional claims for recognition as a medical cautery battery.

The McIntosh Co., of Chicago, makes a well nigh perfect battery for this purpose. The form of cell, plates and method of construction are shown in (Fig. 35). It is called the Sorley accumulator. It is manufactured in three sizes by the McIntosh people, each provided with a rheostat so that the current can be regulated to a nicety. Fig. 36 shows the medium battery. Its amperage is 35, its volt-

age 4. These batteries can be charged from a battery of 16 Grenet cells as well as an electric light wire.

The large type has a current strength of 75 amperes and an electromotive force of 4 volts. Any one can charge either of these batteries by following the directions accompanying them. The current is nicely controlled by the rheostat which is a part of the apparatus, so that the most delicate lamps are maintained at their full height without danger of being destroyed. Caution knives, from the smallest to the largest, are kept at a white heat during the period required for any ordinary operation.



FIG. 36.

If employed to run a surgical engine, the speed can be regulated at will by means of the rheostat.

## CHAPTER X.

### COMBINED, PORTABLE AND OFFICE BATTERIES.

While it is desirable to have galvanic and faradic batteries separate, it is oftentimes a source of convenience and economy, especially to a general practitioner, to have the two instruments combined in one compact portable case.

A large number of very useful instruments are manufactured with this object in view. In selecting a combined portable battery the following points should be sought:

1. Compactness and lightness.
2. Portability without danger of spilling fluids.
3. Connections protected from creeping fluids.
4. Faradic coil with cell power separate from the galvanic portion of the battery
5. The simplest forms of connections consistent with convenience.
6. The combined voltage of the galvanic portion not to be less than 30 when freshly charged.

The combined battery shown in Fig. 37, is a very good one on account of its simplicity. It has twenty-four bichromate of potash cells with zinc and carbon elements of the ordinary size for generating the galvanic current and one cell of the same kind, separate, for generating the current for the faradic coil.

When the cover of the battery box is open, four sections of six sets of elements each, present themselves, and each section is entirely separate and movable from all the rest. The connecting cord, designed for the positive electrode, is attached to the first binding post on the first

section, and the cord designed for the negative pole is bifurcated at one end, and moved along from one binding post to another until a sufficient number of cells have been brought into the circuit to accomplish the work required. The combined voltage of this battery is about 36.



FIG. 37.

The bifurcated or forked cord is for the purpose of preventing a shock while changing to a less or greater number of cells while using the galvanic current.

When the battery is not in use, the elements are lifted into the drip cups, the cells containing the fluid being covered by an overlapping portion of the hard rubber plate to which the elements are attached, and which are lined with cushions of soft rubber. The cover of the box, when closed, presses by means of a spring upon these plates in such a way as to render the cells fluid tight.

The cell for the faradic coil has a similar arrangement for rendering its cell hydrostatic. The battery shown in Fig. 38, manufactured by the Galvano Faradic Battery

Co., possesses the requisite points of a good combined portable battery. In it, the elements which are attached to the rubber plates shown on the surface—ten to each plate—are stationary, and the cells or cups are lifted so as to immerse the elements by means of a rod shown in the background of the cut. When the cells are not in use, the cups are lowered and a closely fitting cover is placed

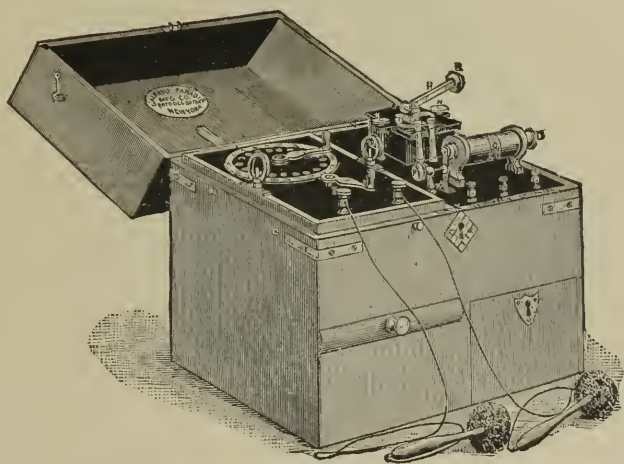


FIG. 38.

over them, and held firmly in position by a rod communicating with the cover when it is closed. This prevents spilling of the fluids in moving the battery. The faradic apparatus with its rubber covered cell occupies one end of the box. This battery has a voltage of about 48 when freshly charged.

The Flemming battery, shown in Fig. 39, has an arrangement for immersing the cells similar to that shown above. The arrangement, too, for preventing the spilling of fluids in transportation is similar. The cells are brought into the circuit by means of a bifurcated cord as shown in the cut. An automatic interrupter for the galvanic current, is also a feature of this battery. The only criticism I am able to make upon this excellent instrument, is that it is rather complicated.



FIG. 39.

## OFFICE BATTERIES.

For office use it is necessary to have a battery that requires little attention, and which can be operated without the necessary loss of time that is required to run a portable battery.

Office batteries should be operated by cells which can be used for a long time without being recharged. The cells best adapted for this kind of work, are the Diamond Carbon, the Leclanche and the Law. These cells will run without losing strength from fifteen minutes to half an hour, when, if they are not allowed to stop, their strength will begin to decline, but with a few minutes' rest they immediately recuperate and will again be ready for action, and with ordinary use will do the work required of an office battery for a year without recharging.

Cells of this description may be stored on shelves in a

cellar or closet, and by means of a cable of wire be connected with a switch board located in some distant room, or they may be stored in a cabinet upon which rests the switch board to which they are connected. Fig. 40 shows a very convenient form of cabinet office battery of the above description. A complete combined battery should possess, besides a circular switch board, with selective arms for the galvanic current, the following:

1. A faradic coil with both a slow and a rapid automatic interrupter, with fine and coarse wire secondary coils.
2. A resistance box with coils varying in resistance from 1 to 100 ohms accurately adjusted and so arranged that any one or more may be switched into the circuit without the others.
3. An automatic interrupter for the galvanic current.
4. A double milliamperemeter.
5. A gradual rheostat.

Such a combination is shown in Fig. 40. The switch board is arranged with 36 buttons, and upon this number 48 Diamond Carbon cells are attached. The buttons numbering to 24 have to each, one cell attached, and the remaining 12 buttons have each two cells. The buttons of the board are arranged in a circle and nearly touch. From an attachment in the center of this circle radiate two movable switch springs, each with its end pressing upon the row of pole buttons. The number of cells in the circuit depend upon the distance of separation of these switch arms. For example: If the first arm is on the button marked (1) and the other on the button marked (10) there are ten cells in circuit, and the number of cells in the circuit at all times depends upon the number of buttons between the terminals of the switches.

A resistance box is necessary for measuring the resistance of any body or part of body that may happen to become a part of the circuit of the battery. This is done by comparing, as explained in the chapter devoted to the

consideration of resistance. An accurate means of measuring resistance connected with an office battery, has become a great necessity in these days of rapid advancement in electric therapeutics and diagnosis.



FIG. 40.

An automatic interrupter for the galvanic current is a necessity of all complete batteries. The device should be such that any number of interruptions from one in a second to the most rapid vibrations can be obtained.

The milliamperemeter should possess two complete coils, either of which can be employed by changing a

switch. It should have a double needle and a double dial. This is to insure accurate measurements of very weak currents as well as currents of considerable strength.

By a gradual rheostat or current controller: I mean an instrument that will enable one to throw into the circuit of the battery a resistance capable of overcoming any current that it is ordinarily desirable to employ, by means of a fine adjustment. This resistance can be gradually withdrawn until a current of any desired strength is obtained for any therapeutic application without the possibility of even the slightest shock. The current is decreased in strength and finally shut off by reversing the former process, that is, by again introducing the resistance.

The gradual rheostat shown in Fig. 41, is the one employed with the battery shown in Fig. 40, and has been used with great satisfaction by the author. It is called the hydro platinum rheostat from its form of construction. Between two small thin sheets of platinum (DD) suspended in water contained in a glass jar of the Grenet cell pattern, is a third plate of platinum (E) with its lower end pointed which can be lowered or elevated in the water between the two other plates by means of a delicate adjustment (C) above. Plates (DD) are both connected with one of the binding posts (A), while the central plate (E) is connected with the other binding post (A). When plate (E) is elevated so that its pointed extremity is out of the water, represented in the bottle, no current can pass between the two binding posts (A) and (A), because there is no connection between the plates. As it is gradually lowered into the water, however, the resistance of the water, while very great at first, when but the point of the plate is immersed,

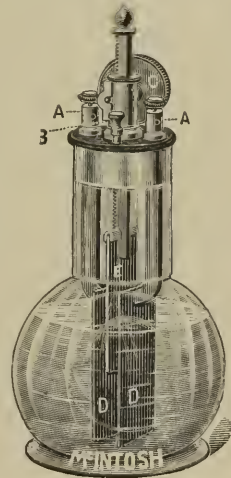


FIG. 41.

admits the passage of a slight current, and as the plate is gradually more and more immersed and the conducting surfaces are increased in area, the resistance to the current is decreased and it becomes stronger until the desired strength is obtained. By reversing the process, the current is again gradually shut off.

With these few words on the principal requirements of an office battery, I must leave my reader to make his own selection from the many excellent instruments in the shops.

## CHAPTER XI.

### CAUTERY BATTERY.

The student is referred to the chapter on selection of current for a minute description of the difference between the cautery current and the ordinary galvanic current. A current for galvano-cautery work such as is required in gynecology, should be of 40 ampere and electromotive force of not more than four volts. In other words, a current of quantity, not intensity, is required, one which may be obtained (a) from ordinary cells of large elements, (b) from a dynamo wound for quantity (c) from storage batteries.

#### (A) GALVANIC CELL CAUTERY.

The battery employed by the author of this variety, is shown in Fig. 42. It is well constructed, compact, portable and reliable. It can be carried any distance, charged, and be relied upon to furnish energy for any ordinary operation without recharging. It is constructed so as to furnish a large surface in a small space thereby lessening resistance and increasing amperage. The cells and drip cups are of hard rubber. The current is graduated by a device which allows the elements to be lowered and heightened in the exciting fluid. The elements are zinc and platinum, and the fluid bichromate of potash and dilute sulphuric acid. Fig. 43 shows the McIntosh stationary cautery battery, which is a very simple and reliable machine for office work. Simplicity of construction is the great desideratum in the cautery battery.

## (B) CAUTERY CURRENT FROM DYNAMO.

The ordinary street current used for incandescent lighting, is not suitable for cautery work because of its high voltage. A dynamo should be specially wound which is designed for cautery work. Through my efforts, Mr.

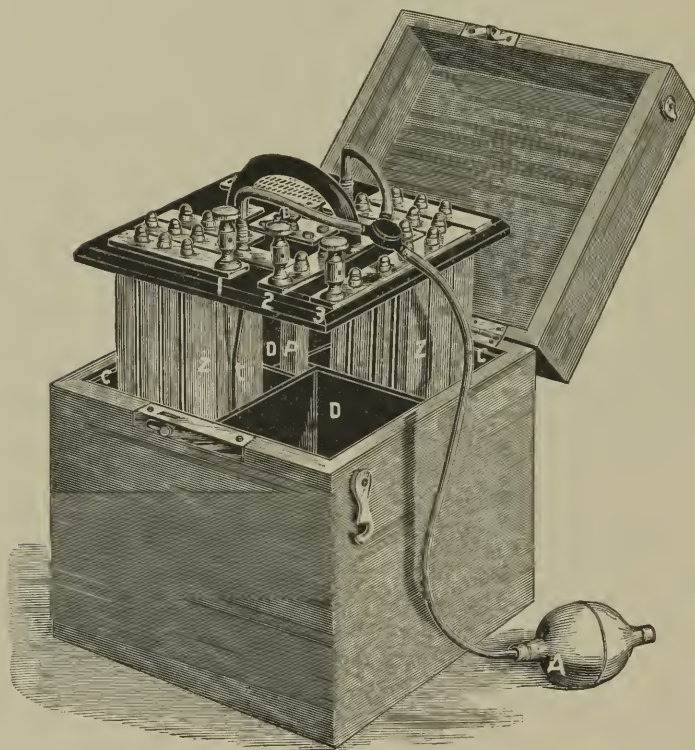


FIG. 42.

Elmer A. Sperry of Chicago, was induced to construct a medical dynamo which has double windings, and which, in consequence, furnishes two distinct currents; one of which is suitable for medical cautery work. The cautery current is of a strength of 40 amperes and an electromotive force of 4 volts. For description, see page 58, Fig. 26, which shows this dynamo. The current is regulated (increased

from zero to its maximum strength) by changing the position of the brushes.

(C) STORAGE BATTERIES FOR CAUTERY.

The storage battery is especially adapted to cautery work. The small voltage and large amperage of the ordinary accumulator cell, makes it a compact form of storing energy for ordinary work of this kind. In gynecological work either the largest or medium size Fig. 35, described in the chapter on storage batteries, is suitable.

**Relative value of the three different methods of obtaining the cautery current.** If one is not called upon to use the cautery battery frequently, or is living in the country, away from an incandescent system of electric lights, he should have the ordinary *galvanic cell cautery*, Fig. 42. This battery

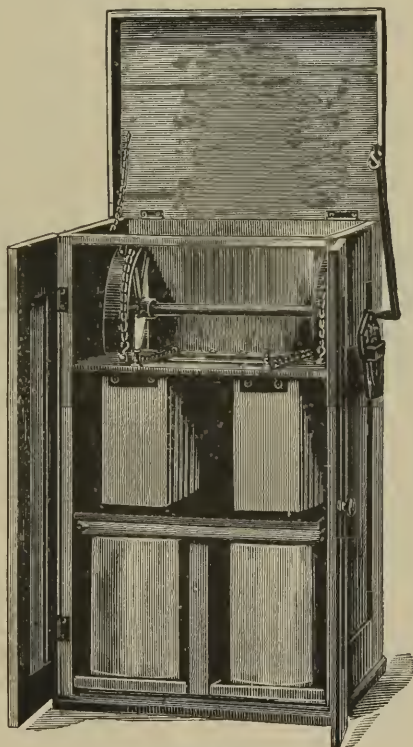


FIG. 43.

he can easily charge for each operation in which it is required, the fluid afterwards can be thrown away, the cells washed and set aside without fear of deterioration, until it is required for an operation even months in the future. Even where it is recharged for each operation, it is an economical battery.

If one requires the daily use of a cautery battery, and

is in a position where a storage battery may be charged from an electric light wire, he may employ to advantage the storage cells Fig. 35. A storage battery should be used pretty constantly to be used economically. It deteriorates rapidly when not in constant use.

The Medical Dynamo can only be used with advantage for stationary work, and then only when there is some form of power at hand which will operate it. A water, electric, or gas motor may be used for that purpose. Of course, if steam power is at hand, it should be utilized.

#### CAUTERY ELECTRODES AND HANDLES.



FIG. 44.

A handle for a cautery knife, or wire or electrode, should be constructed of insulated material containing the metal connections in its interior. The handle should be light and have on it a switch for turning on and off the current, which can be operated with the thumb or a finger of the same hand that holds the instrument. The best insulating material for such handles, is hard rubber because of its lightness. The handle used by the author is shown in Fig. 44. This has also an ecraseur attachment for



FIG. 45.

shortening the wire loop which is operated by the thumb. Fig. 45 shows this handle with the loop adjusted.

Galvano-cautery electrodes are constructed of many shapes and sizes. Any of the electrodes shown in Nos. 1, 2, 3, 4, 5, 6, 7, 8 and 9, Fig. 46, may be used in gynecological work about the vagina, uterus, bladder or rectum. No. 4, Fig. 46, with a longer shank makes an excellent curette. No. 2, Fig. 46, with uterine curve, also makes an excellent intra-uterine cautery instrument.

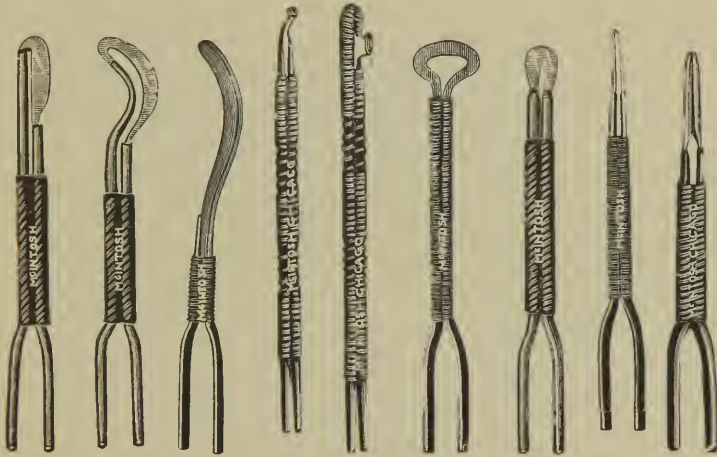


FIG. 46.

## CHAPTER XII.

### EMPLOYMENT OF INCANDESCENT STREET WIRE CURRENTS FOR THERAPEUTIC PURPOSES.

The therapist who is fortunate enough to be located in the vicinity of an incandescent electric light wire current of the uninterrupted variety, possesses a very convenient substitute for the galvanic battery. The Edison system, with its 110 volt current, is the one most frequently employed for general electric lighting, and the one which is most popular with the electro-therapist. Any system, however, which is smooth, uninterrupted, not alternating, of comparative small amperage and of a voltage of not more than 110 volts, may be adopted.

As this current is flowing steadily, always of the same voltage, it is necessary of course, to have some means of modifying its strength and of subduing it to the delicate requirements of the physician's office. This is accomplished by means of some form of rheostat, called also a current controller. A current controller is a device by which a current of any given strength may be increased or decreased at will, with absolute gradual gradations from zero to the maximum strength of the current controlled.

#### MCINTOSH HYDRO-ALUMINUM RHEOSTAT.

This instrument described on page 81, may be employed in the circuit of the Edison incandescent, as a current controller. It is one form of a water rheostat and answers the purpose fairly well, although it is by no means ideal.

## BAILEY RHEOSTAT.

This instrument, Fig. 47, has been used quite extensively and successfully for controlling the electric light wire. It, too, is a form of water rheostat, and like all instruments with the same principles involved, is not entirely satisfactory.

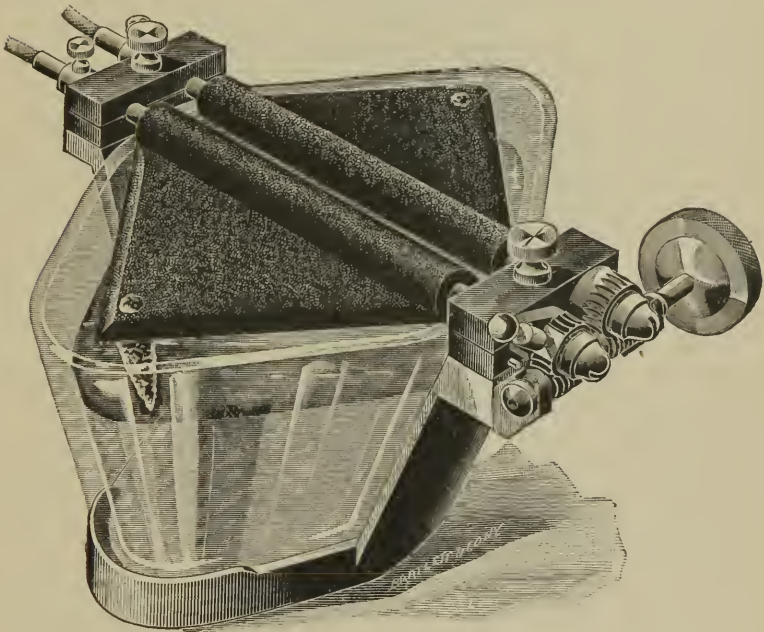


FIG. 47.

The McIntosh instrument is employed in the following manner: The central plate is set so that it does not come in contact with the water. When in this position, no current can pass through the instrument. The instrument is placed in the circuit by attaching one of the supply wires to one of its binding posts; from the other binding post, a second wire passes through the milliamperemeter to one of the electrodes to be employed on the patient. The circuit is completed by a wire leading from the other electrode to the second supply wire from the street.

## THE MASSEY CURRENT CONTROLLER.

Dr. Massey, of Philadelphia, the inventor of this excellent instrument in describing it, says: "Its function is to vary the current at will, by rapidly increasing or decreasing the resistance of the circuit. It will now, as improved,



FIG. 48.

vary a current from a fraction of a milliampere to the full strength of the battery without shock."

"It consists, Fig. 48, of a ground glass plate provided with a tapering area of soft pencil mark, broadening into thick graphite embedded in the glass, which is joined to lead. These act as a resisting material, over which a brass contact attached to a crank can be made to pass. When the crank (1) is placed to the right of the hard rubber button (2), the contact rests entirely on the glass and the circuit is broken. Moving it slightly in the direction of the arrow, it soon touches the graphite mark and permits the least amount of current to pass through the whole length of the graphite—a poorly conducting medium. As the crank is slowly brought down from the point of rest and up the other side, there is a progressive, gradual

increase of current, until finally, the thick graphite and the lead at the left of the rubber button is reached, when the whole power of the generator or battery is turned on, there being no resistance remaining in the controller. A reverse action turns the current off. The screw at (3) is for breaking the circuit and should be screwed *in* when using the instrument."

"Special attention should be paid to the following points in order to prevent mishaps and to retain the full working capacity of the controller:

"1. Always place the turning crank to the right of the rubber button before applying the electrodes to the patient, so as to be sure that the full resistance is interposed; otherwise an unpleasant or even dangerous shock to the patient might result.

"2. After the electrodes are in place, turn the crank down and toward the left *slowly* until the meter shows the desired current strength.

"3. If using an incandescent current, never bring the metallic part of the cords or electrodes together unless the crank is well over to the *right*.

"4. Prevent all dust from settling on the glass plate.

"5. Renew the graphite covering on the glass plate as often as marks of wear are visible by rubbing graphite over the circumscribed area from a *very soft pencil*."

The Massey instrument for use is attached to the street wires in the same manner as the McIntosh and Bailey instruments.

#### THE GISH RHEOSTAT.

The Gish Rheostat, Fig. 49, is particularly adapted for street wire work. It is large, strong, well constructed, and controls a powerful current with the greatest nicety. Its simplicity of construction and action recommends it highly to the practitioner. The principle of the shunt is employed in the construction of the instrument.

## DIRECTIONS FOR OPERATING.

1. Always have the movable handle, H (see cut) at the mark, SP, before closing the switch.
2. Attach all instrument wires to the two binding posts, L and L.
3. Switch, S, is closed when the handle is resting over the word On.

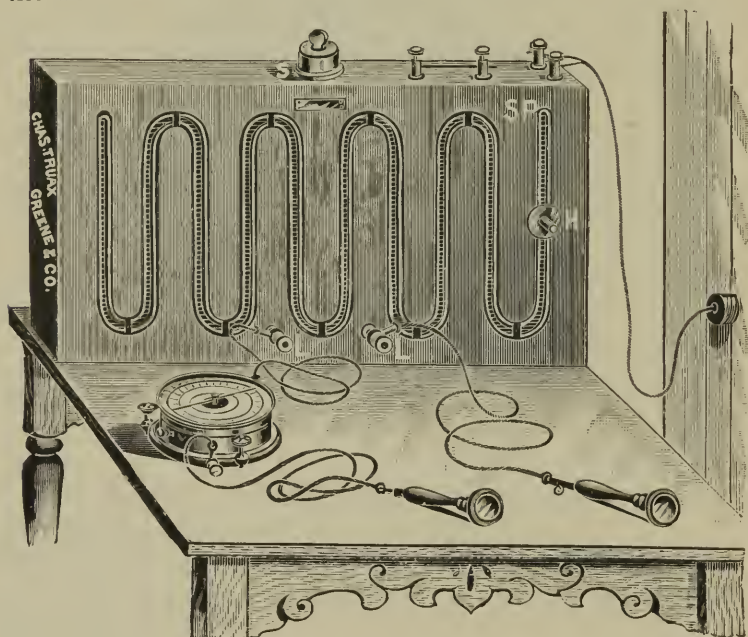


FIG. 49.

4. Although the switch is closed there will be no current through the instrument wires, or to the patient, until the handle, H, is gently moved along its way, and the further it is removed from the mark, SP, the stronger will be the current, until as much electricity as is desired has been obtained.

5. When the work is finished return the handle, H, to the mark, SP, and open the switch. Neglect of this rule may cause damage.

6. To obtain the faradic current from this rheostat, run the conducting cords from the binding posts, L and L, to the positive and negative binding posts on the induction coil; now, by simply changing the position of the handle, H, to a greater or less distance from the mark, SP, the current will be modified accordingly in the induction coil without changing the interrupter or withdrawing the tube.

7. In using a rheotome, connect it in series with the patient.

8. A standard milliampere meter should be employed in all galvanic work.

## CHAPTER XIII.

### MEASUREMENTS.

Electricity, taken in a comprehensive way, so as to include its various phenomena, must now be considered as an exact science. In dealing with known substances, our first impulse is to speak of them in definite quantities. Until very lately, as medical men, we have been much embarrassed in speaking of the dosage of electricity. Within fifteen years a decided change has come. Electricity can now be measured, stored and transported, and can be dosed as accurately as quinine or morphine.

In the measurement of electricity, three factors must be taken into consideration, any two of which can determine the third. These factors, with which we are already slightly acquainted, from considerations in another chapter, are:

- 1st. Current, C, measured in *amperes*.
- 2d. Electromotive force, E, measured in *volts*.
- 3d. Resistance, R, measured in *ohms*.

*Current in electricity* means the rate of passage of unit quantity of electricity across any section of conductor.

The current is directly as the electromotive force and inversely as the resistance, and hence:

$$\text{Ohms formula—} C = \frac{E}{R}$$

Thus each influences the other, and the three must be borne in mind in making our calculations.

*Current* is measured by three actions peculiar to it.

- 1st. Its action on the magnet.

2d. Its chemical action.

3d. Its action in producing heat.

The instrument that measures the current by its effect on the magnet, is called the *Galvanometer*.

The instrument that measures the current by its chemical effect, is called a *Voltmeter*.

The instrument that measures the current by its heating effect, is called the *Calorimeter*.

Of these instruments, the first, or the Galvanometer, is the one that specially interests us as physicians, because it is the form of instrument generally adopted for measuring the current for therapeutic purposes.

**Galvanometer.** When a galvanic conductor and a magnetic needle are placed parallel, they immediately attempt to assume a position at right angles to each other. As this action is alike strong in both, and as the action obeys definite laws, obviously a means of testing the current of any conductor is made possible by this action on the magnetic needle. The needle being the lighter body, it is made the movable one in practice.

If a magnetic needle is suspended by its center so as to lie horizontally, and over it, in the same direction is placed a conducting wire with a current entering at the southern end, the needle turns with the N end to the left or westerly. If the wire is allowed to return below the needle, it continues to turn in the same direction, its movement being re-enforced by the action of the current below. If now, the current is reversed and allowed to pass in a direction from N to S above and from S to N below, the N point of the needle will turn easterly or in the opposite direction to that in which it turned before.

Upon this action of the galvanic current upon the magnetic needle, a large number of galvanometers have been devised, some of which are very intricate in their construction. I must confine myself, however, to general laws, and in the simplest way point out the principles upon

which the galvanometer for medical purposes should be constructed, and present illustrations of those which best serve the purpose of the therapist.

The principles of a galvanometer are represented in the flat coil of wire and magnetic needle shown in Fig. 50. When there is no current in the coil of wire, the needle, from the action of the magnetism of the earth, assumes a north and south position. When a current of electricity traverses the wire, the needle is deflected a certain number of degrees according to the strength of the current. A given strength of current will always deflect the needle a definite number of degrees if the conditions remain the same. If then, upon a dial, over which the magnetic needle is suspended, the value of different degrees of deflections are marked, which are ascertained by passing through the coils known currents of different strengths, we have the essentials of a galvanometer in their simplest form.

Let us now apply these essential principles in practice. The galvanometer shown in Fig. 51, is one employed

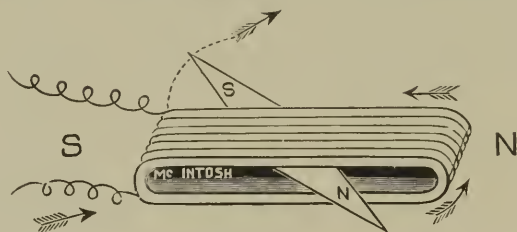


FIG. 50.

for measuring currents for therapeutical purposes, and has proved itself to be a very reliable instrument. It is strongly and simply constructed and covers with approximate accuracy a long range of measurements.

The long slender indicator shown on the face of the dial is of steel and is attached to the magnetic needle so that its direction lies at right angles to it, pointing east and west when the magnetic needle is north and south. The

indicator and the needle are attached by means of a small hollow cylinder about one half inch in length into the upper end of which is fitted a small agate jewel, which balances upon a hardened steel pivot projecting between the coils from the frame below. When the needle and indicator are balanced, the needle swings between the coils of wire and the indicator above them as shown in Fig. 52; and when the coils are placed within the case and all attachments are complete, the indicator swings over the face

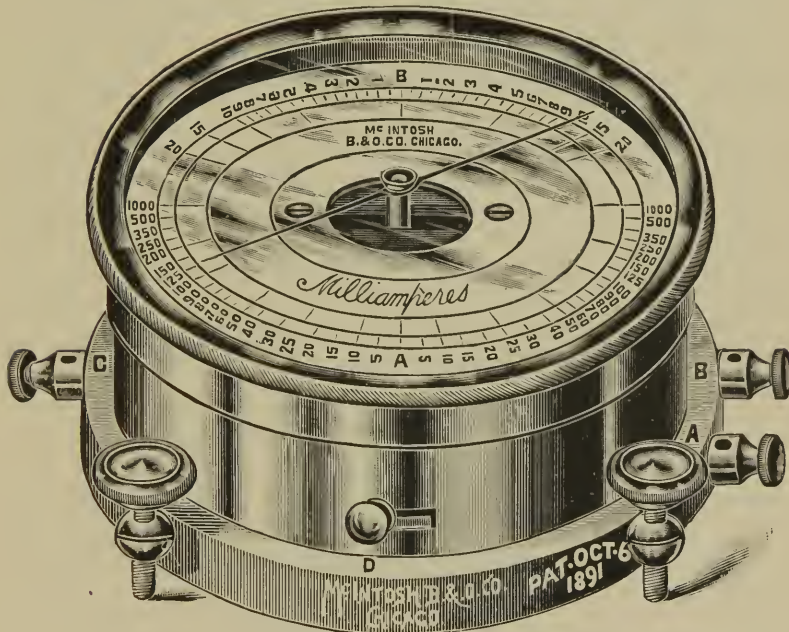


FIG. 51.

of a properly engraved dial, as shown in the complete instrument, Fig. 51.

With the use of electricity in medicine, it has been found that it is necessary to employ currents of great diversity of strength. For example, in nervous diseases, and in the use of the galvanic current about the eyes and ears, the maximum strength of current often will not ex-

ceed 20 milliamperes, while in gynecological practice the maximum current may consistently be stated as 300 milliamperes.

From this, it may easily be appreciated that two instruments are necessary for every medical apparatus, one for measuring strong currents, and a second for measuring weaker ones, unless the difficulty is obviated by constructing an instrument with a double coil and a double dial. That has been accomplished in the instrument under consideration. By reference to the dial of the meter in Fig. 51, it will be noticed that one side is registered to 20 milliamperes with appropriate gradations, while the other side is registered for 1,000 milliamperes, with gradations. The difficulty, not to say impossibility, of accurately measuring gradations of 20 milliamperes on the scale graduated for 1,000, must be obvious to all. It is also obvious that two systems of windings are necessary when two deflections of entirely different values are desired.

In the McIntosh instrument the two windings will be readily understood by referring to Fig. 52. *First*, about

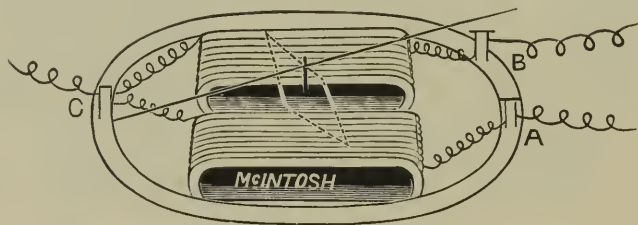


FIG. 52.

7 feet of No. 18 double covered copper wire is wound upon two parallel frames, so that an equal amount of wire occupies each, and the two ends are attached to binding posts A and C, respectively. *Second*, about 46 feet of No. 30 covered copper wire is wound upon the frames over the first and coarser wire so that an equal amount occupies each, and the two ends are attached to binding posts B and C. If a current is passed through the large wire which ter-

minates in the binding posts A and C, the value of the deflections are indicated on the side of the dial graduated for the stronger currents from 0 to 1,000 milliamperes. If, on the other hand, the current is passed through the finer wire which terminates in the posts B and C, the value of the deflections are indicated on the side of the dial graduated for the weaker currents from 0 to 20 milliamperes.

The McIntosh milliamperemeter complete, is shown in Fig. 51. Upon the center of the base which is supported by three leveling screws, rest the coils, between which is the needle, connected through an opening in the dial with its indicator above. Around the coils resting upon the base, is a round brass case into the top of which is fitted a glass cover. The dial which is of polished brass and well engraved, is supported by the brass frame over which the coils are wound. A switch at D, lifts the indicator off its delicate pivot when the instrument is not in use, and renders it possible to carry it without danger of injuring the delicacy of its contact. To either side of the base are attached the binding posts with appropriate markings.

#### TO USE THE INSTRUMENT.

Release the indicator by sliding the button D to the right. Place the instrument so that the indicator rests at 0, which will be due east and west, and adjust the leveling screws so that the dial is perfectly horizontal and the indicator swings free.

**To use the long scale.** Connect the positive pole of the battery with binding post C, and the patient with post A, by means of a conducting cord and electrode. When the patient is connected with the negative pole of the battery, the circuit is complete.

**To use the short scale.** Connect the positive pole of the battery with binding post C, the patient with post B, by means of the negative pole to the battery, and as before, the circuit is complete.

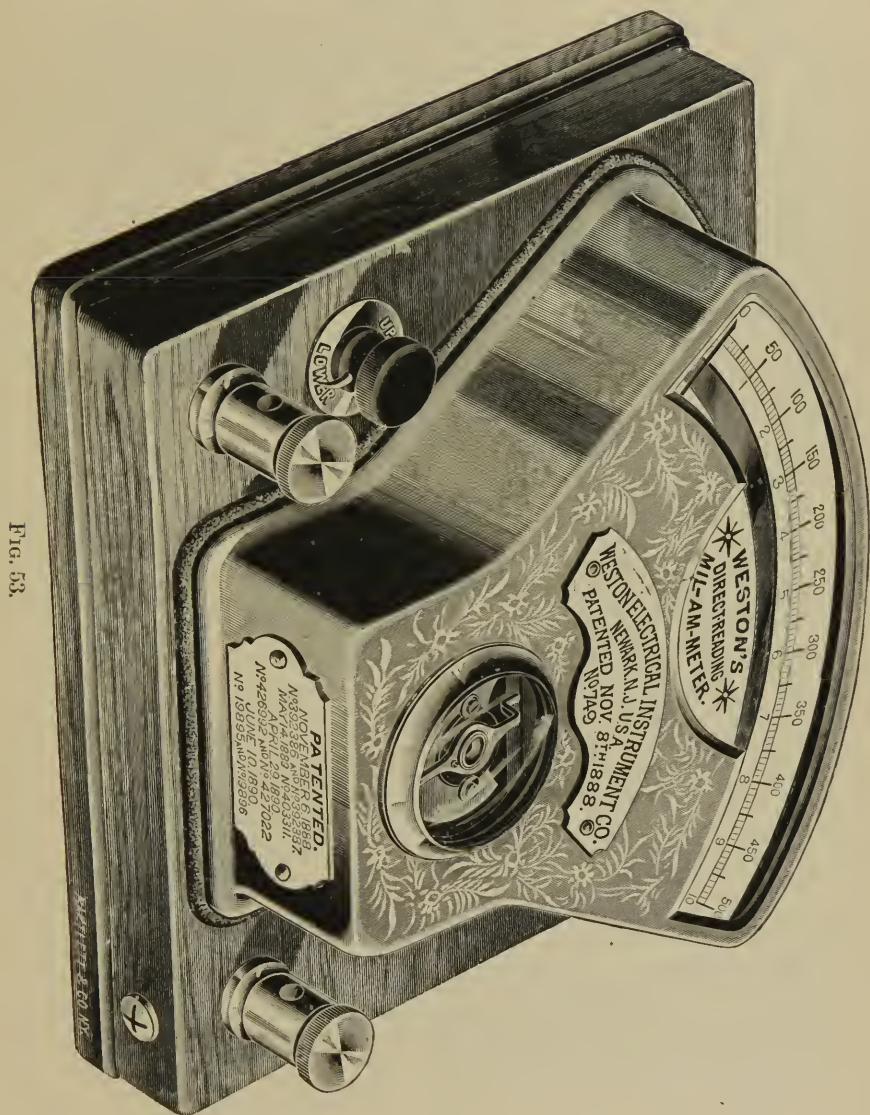
## VERTICAL GALVANOMETERS.

For some reasons, it is common to arrange the needle in a vertical plane mounted on a central pivot. With this form there are two needles, one working inside the coil, the other with reversed poles working outside. While such instruments have their uses, they are not as reliable as the horizontal kind. The horizontal variety depends upon the magnetism of the earth, which can be said to be approximately uniform for its resistance, while the vertical variety depends upon the varying magnetism of its needle for attraction, and the weight of the lower part of the needle for its resistance. The chief advantage of this variety, is the lack of vibration in its needles and its ready visibility from a distance.

## THE WESTON MILLIAMPERE METER.

I copy a description of this instrument from Atkinson's *Dynamic Electricity and Magnetism*: "This instrument, shown by Fig. 53, incloses within its case a powerful steel horseshoe magnet, the poles of which project into the narrow space in front, and are attached to two soft iron pole pieces. These inclose a circular space, within which is mounted a soft iron armature core, maintained in a fixed central position by attachment to a brass yoke which connects the pole pieces. A light copper frame  $\frac{3}{8}$  of an inch wide, and wound with a coil of insulated copper wire surrounds the core, and has a limited rotary motion, on jeweled bearings, in the narrow space between the core and pole pieces, which is just wide enough to allow rotation without contact.

"The terminals of the coil are connected above and below with two flat springs, oppositely coiled, and so attached to the copper frame and adjoining parts as to maintain the coil in a fixed position when the springs are not under tension, and bring a light aluminum pointer, attached to the frame, to zero of the scale.



“These springs are made of special, non-magnetic alloy, and are placed in opposition to neutralize the effects of expansion and contraction under variations of temperature.

"A resistance coil, mounted within the case, makes electric connection by one of its terminals with one of the springs, while the other terminal is connected with the front binding post on the left. Another connection with the rear binding post on the same side, taps this coil at a point nearer the spring, so as to include a much lower resistance. The other spring is connected with the binding post on the right back of which is a contact key and a calibrating coil.

"When connections with an electric source are made by the right binding post and either of those on the left, the current enters and leaves the copper coil through the springs, its direction and the winding being such as to produce deflections from left to right, the coil tending to rotate into a position at right angles to the lines of magnetic force, in opposition to the tension of the springs. And the instrument being calibrated in accordance with the resistance of its coils, the deflection of the pointer will indicate the difference of potential in volts; since with a given resistance the electromotive force or potential difference varies directly as the current strengthens."

The above is a description of the Weston voltmeter.

The milliammeter is practically the same instrument with the copper coil of coarser wire, therefore of less resistance and without the necessity of a resistance coil.

The instrument shown in the cut has a scale of double value, one reading from 0 to 500 ma., the other from 0 to 10 ma. The change from one scale to the other is made by changing the switch on the left of the instrument, the scale to read being indicated by the pointer "upper" or "lower."

This instrument can be used as a voltmeter by the employment of a small resistance box furnished with it, which has two values; when used in connection with the

lower scale, reads to 10 volts by  $\frac{1}{10}$  volt divisions, and to 100 volts by single volt divisions.

Attention is called to the following specific advantages of the Weston milliamperemeter:

1. Although the scales of these instruments are remarkably uniform, no particular "law" of deflections is assumed, as must be done when printed or engraved scales are used. A skeleton of each scale is laid out by actual comparison with an accurate standard, and the lines afterward inked in. Finally, the work is checked by comparison with the same standard.

2. The instruments are direct reading. No multiplying constant is necessary, as simple inspection of the position of the pointer on the scale gives the value in milliamperes or volts. Time in making readings is therefore saved, and errors of calculation avoided.

3. All scale readings begin at zero, and extend by practically uniform increments to the maximum reading. The range is thus greater than is common, while the uniform size of the scale divisions permits of their visual subdivision with uniform accuracy.

4. The instruments are remarkably "dead beat." The pointer comes to rest at once, *although absolutely no friction can be detected*, thus reducing the time required for readings, and preventing unnecessary wear of the moving parts.

5. There is no "magnetic lag," giving rise to different deflections with the same current or potential, as in instruments having iron in the moving parts.

6. The instruments can be kept in circuit any length of time, as the heating effect, except in the higher ranges, is so small as to be unappreciable.

## CHAPTER XIV.

### POLES, CORDS AND ELECTRODES.

In the application of electricity there is much to consider besides a means of generation of the proper current. We may have a proper source of battery power and still be unable to accomplish any work without a knowledge of the direction of the current, a means of conducting the current from the generator to the patient, and a proper means of diffusing the current properly by means of electrodes when we have succeeded in bringing the patient into the circuit of the current. This also leads us to a consideration of the density of the current which is almost as important as the consideration of its strength.

#### POLES.

A current of electricity leaves a battery or generator in an external circuit from the positive pole and flows in a direction, from the positive to the negative, entering the battery again at the negative pole. Therefore, the end of the battery from which the current emerges, is called the *positive pole* or *anode*, while the other end is called the *negative pole* or *kathode*.

There are different ways by which we may distinguish the poles. In the ordinary zinc and carbon batteries, the current leaves the battery from the carbon side, or the sides of the element of greater potential, and in all batteries of whatever construction, the element of higher potential represents the positive pole. The poles can often be distinguished by the sensation. When two sponge electrodes

are placed upon a portion of the body, and a current of considerable strength is turned on, a more intense burning is experienced at the negative or kathode than at the opposite pole.

The poles can often be distinguished by the taste. If the metal terminals of two conductors, one at a time, are placed upon the tongue, the negative pole or kathode will leave an alkaline taste, while the positive terminal will have a sour or acid taste. As a last resort, the poles may be distinguished by plunging their metal terminals into a solution of iodide of potash when from an electrolytic process the brown iodine will gather around the positive pole.

#### RHEOPHORES.

The connecting cords or wires between the battery and the electrodes, are called the *rheophores*. Rheophores are constructed in different ways by different instrument makers. The *rheophores* for a battery with high electromotive force such as is employed for ordinary galvanism, should be long and flexible, and are best constructed with fine strands of copper wire covered with a layer of woven silk or rubber tubing.

The rheophores for a cautery battery must be large and not too long, so that their resistance is reduced to a minimum, because the electromotive force of this battery is small, and its power to overcome resistance is very slight.

#### ELECTRODES.

The current is applied to the body by means of electrodes. Electrodes are constructed in many forms and sizes in order to meet the multiform purposes for which they are employed.

The author, for ordinary external use, prefers metal electrodes covered with sponge or chamois, or absorbent cotton.

The one shown in Fig. 54, is convenient for diagnostic purposes, and is called the standard electrode. It has a



FIG. 54.

surface of 10 sq. c. m. The pointed electrode of the same construction is employed for localizing the current about



FIG. 55.



FIG. 56.

the face or other delicate parts and in selecting nerve points for stimulation. The electrode shown in Fig. 55,



FIG. 57.

is the small hand electrode that is employed in giving general surface applications. A larger hand electrode for the same general purpose is also convenient. The

large square electrode, Fig. 56, is for applying the current to the feet of the patient. The electric brush, one form of which is shown in Fig. 57, is made in many forms, and is for the purpose of applying currents superficially to the skin. These are a very few of the many electrodes which have been constructed to please the fancy and ingenuity of many operators, and in the list are included none of the electrodes for special purposes, these being purposely reserved for description in their proper places in considering special subjects.

## PART SECOND.

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### CHAPTER XV.

#### ELECTROLYSIS.

*Electrolysis* is the power possessed by the voltaic current of chemically decomposing a compound body into its constituent elements.

An *electrolyte* is that body or substance which is capable of being dissolved into its several elements by means of an electric current.

The *ions* are the product of electrolysis or the constituent parts into which an electrolyte has been divided by the current of electricity.

When the two electrodes from a galvanic battery are plunged into a solution containing electrolytes to be decomposed, a definite proportion of the *ions* are attracted by the positive pole, while the remainder are attracted by the negative pole. Those which are deposited or attracted by the positive pole or anode are called *anions*, while those which are deposited or attracted by the negative pole or kathode are called *kathions*.

Every compound body contains two varieties of elements. Those which upon electrical decomposition of the body are attracted by the negative pole, are called electro-positive elements, while those which are attracted to the positive pole are called electro-negative elements. In electrical decomposition, as in all other electrical phenomena,

therefore, it will be noticed that a given pole only attracts bodies of an opposite polarity.

An electrolyte must be in solution in order to become electrolyzed.

If now, we take water as a sample electrolyte, and place in it two platinum electrodes, one from each pole of a galvanic battery, and cause a current to traverse the water from one pole to the other, we will get electrolysis. Every molecule of water, which is reduced to its constituent elements in this way, is broken into two atoms of hydrogen and one atom of oxygen. Hydrogen and oxygen, then, being the result of electrolysis of water, they are the *ions*, and, as hydrogen is liberated at the kathode it is the *kathion*, and as oxygen is liberated at the anode it is the *anion*. As hydrogen is attracted by the negative electrode, and oxygen by the positive electrode, they are respectively the electro-positive and the electro-negative elements of water.

The pretty theory of electrolysis which is based upon facts is substantially as follows: In every compound, as we have seen, one of the elements is electro-positive, the other electro-negative. If a molecule next the positive electrode be decomposed, the electro-negative constituent of the molecule is attracted by that pole, thereby setting free the electro-positive constituent which immediately grasps and combines with the electro-negative element of the next molecule, and so on, until every molecule has been similarly acted upon in the line of the current and the negative electrode has been reached; to this, the last electro-positive element liberated, will attach itself.

#### CATAPHORIC ACTION OF THE GALVANIC CURRENT.

Closely associated with electrolysis we have the phenomena, electrical osmosis, or the cataphoric action of the galvanic current. This consists in a direct transference of liquid particles by a continuous galvanic current in a direc-

tion from the positive to the negative pole. The phenomena differs from electrolysis in that it produces movement of unbroken molecules when in solution, creating a current of the whole mass of fluid acted upon in the direction of the electrical current. This action can be demonstrated in a simple way by placing the electrodes of a voltaic machine in two compartments of a fluid separated by a porous septum, when it will be observed that the fluid particles pass in the direction of the current of electricity, by the fluid in one compartment of the disk increasing in volume at the expense of the other.

Late writers have been inclined to attribute to the two phenomena, electrolysis, and electrical osmoses, many of the brilliant results which have been accomplished by the use of the galvanic current in the treatment of disease. While there is no doubt that these two effects do have a profound influence in a certain class of cases, we are not warranted in the light of our present knowledge in accepting them for more than strong factors among other influences of electricity in effecting cures.

That electrolysis does occur, however, in living tissues, we have abundant proof. When it is remembered that from one half to two thirds in bulk of the human tissues of the body is water, we can, at least, readily understand why electrolysis should occur under proper influences. While the galvanic current passed through a soft living tissue, has not an uninterrupted fluid medium, it has, practically, a fluid medium divided into innumerable little compartments, each one separated from the other by a thin wall of solid. During the passage of the current, each of these particles of solids acts as a positive electrode on the fluid between it and the solid particle in front of it. Each molecule of fluid in a conducting solid therefore, in the line of a galvanic current, may become electrolyzed.

It has been abundantly demonstrated that in the passage of a galvanic current through a portion of soft

living tissues of the body, that a decided cataphoric action is engendered. This may occur by a direct transference of the fluid particles through the little permeable walls of solid in the direction of the negative pole of the battery.

Thus we may have these two effects of the galvanic current upon soft, fresh living tissues: 1. A separation of the combined elements in solution (more or less according to the density of the current) into their constituent elements, and a rearrangement of the same. 2. A general movement of elements in solution towards the negative pole of the battery.

Now, are we not in a position to explain how tissue-change, or absorption even, may be promoted by these two factors alone, when applied to living normal tissues? A galvanic current of moderate or decided strength is made to traverse a portion of living tissues and the most susceptible molecules in the course of the current become broken into their original elements. (1.) These liberated elements immediately make a similar or different combination with neighboring elements of opposite electrical tendencies, making thereby new compounds which act as foreign particles; as foreign particles, they are promptly removed by the nearest absorbent. (2.) Other elements, as they become free from their original molecules, make combinations with elements which are already leaving the tissues through one of their innumerable minute vascular or absorbent canals. (3.) Many in the form of gas, pour into the atmosphere beneath and surrounding the electrodes. (4.) Others attack the electrodes and are disposed of in the form of deposit on their surfaces. (5.) The current by its cataphoric action, produces an engorgement of the tissues at the negative end of the circuit. The absorbents in that portion of the tissues will promptly make an effort to establish an equilibrium, and by a direct action of endosmosis, they are filled and the excess is carried away in their currents.

A similar change to the above, we can naturally expect in pathological tissues alone, or in pathological tissues incorporated with normal tissues. The ultimate effect, however, on the two tissues of repeated electrolysis, must be different because of the constant effort upon the part of non-pathological or normal tissue to repair itself, and the inability, with few exceptions, of pathological tissues to do so.

If the successful application of the above principles were subject to no exceptions or doubt, our course in the application of galvanism to the cure of diseases, would be clear indeed. We are not so fortunate, however:

1st. Because electrolysis only occurs at the electrodes, it is claimed, and that no electrolytic action is possible in the proper inter-polar region.

2d. That the vitality of living tissues is a barrier to the characteristic effects of electrolysis in their interior.

3d. That it is impossible to obtain sufficient density of current in highly sensitive tissues to make electrolytic action possible.

The first objection, viz., that because electrolytic action occurs only at the poles, therefore, proper inter-polar electrolysis does not occur, is only partially sustained by theory and not at all by fact.

If we mean by poles, the electrodes of the battery, we are certainly at variance with the facts. If we mean by poles, every solid or semi-solid particle in the line of the current as it traverses animal tissues, then the theory can be accepted. Because there is no doubt that where a current of considerable density is made to traverse a portion of fresh muscular tissue, that electrolytic action occurs at each solid portion of tissue of whatever nature it may be. And when we realize that thousands of these little electrodes may be met with in a very small portion of tissue, it is easy to understand how interstitial electrolysis may occur and still only at some form of a pole.

If we take two clean steel needles attached to the two poles of a galvanic battery, and insert them about one inch apart into fresh living muscular tissue, the following phenomena will be observed after a moderate current has passed for five minutes. Around the positive needle will form brownish black scales of peroxide of iron, from the oxidation of the steel by the oxygen liberated at its surface. Around the negative pole will be gathered small drops of water, and a constant bubbling of escaping hydrogen gas will occur as long as the current is active. If now, this portion of tissue is removed bodily, the greatest effect of the current will be noticeable at the points of insertion of the two metallic needles. This fact is explainable because of the greater density of the current at these two points. Surrounding the positive needle for some little distance and gradually shading off, will be noticed a hardening of the tissues with almost, if not quite, disappearance of all normal tissue structure. This portion of the tissue if macerated and washed, will produce a resultant liquid of a strong acid reaction. While, if on the other hand, the negative electrode is examined, the tissue surrounding it will be found softened and white, resembling the cauterizing effect of caustic potash. The needle will be found freely movable and its surface covered with a frothy deposit caused by the bubbling of hydrogen gas through water. The structure of the tissue for some little distance around this pole is more or less destroyed according to the strength of current employed. The reaction of the resultant *ions* at the negative pole will be found distinctly alkaline in reaction. If now, the portion of tissue lying between the poles, be examined carefully with a microscope, a change will be noticed in its structure. Minute bubbles of hydrogen will be found well distributed through the structure, paleness of the sarcolemma and partial disappearance of the striae together with granular collections distributed in the tissues will also be observed.\*

\*Amory Treatise on Electrolysis.

When we remember that these phenomena are noticed in tissues acted upon while living, we can readily understand how much of the products of electrolysis might be removed by the active absorbents before the tissue could be properly prepared for critical examination.

Davy was one of the first to prove that electro-positive elements will collect at the negative pole and vice versa; and that if the well washed fingers constitute the electrodes, the electrolyte gives the same reactions around the poles as with dead substances, thus showing that living acts like dead matter. (Amory.)

This same investigator immersed the ends of a piece of fresh meat into two dishes of distilled water and attached their ends to the respective poles of a galvanic battery. At the negative pole he found potassa, soda, lime and ammonia, and at the positive pole sulphuric, hydrochloric, phosphoric and nitric acids. While the piece of flesh was entirely deprived of its salts.

The following experiment of the author, seems to prove that electrolysis takes place throughout the whole line of

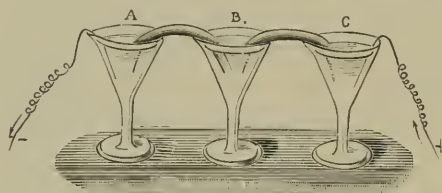


FIG. 58.

an animal tissue circuit and not merely at the terminal metal electrodes. The manner of the experiment is similar to one of Davy's which has been

familiar for a long time, and which has been often quoted as proving that electrolysis only occurs at the true poles of the battery. The experiment of Davy, which I quote from Amory (page 35), is as follows, Fig. 58: Fill three vessels (a) with a solution of litmus and sulphate of soda or common salt, (b) with litmus and water, and (c) with a solution of litmus, and place between the three vessels some wicking, whose ends are immersed in the solution; place these all in line or in circuit, with an electric battery

as represented in (Fig. 58). If a strong galvanic current is then made to traverse the entire circuit, the litmus in vessel (c) will assume a red color (acid reaction at the positive electrode) and remain blue in vessel (a) (alkaline reaction at the negative electrodes) the salt will be found to have passed from the first to the other two vessels, and the litmus solution in (b) will still remain blue (neutral). If the current be continued for a sufficient time, the salt will be found to have been entirely decomposed; the acid being found in (c) and all the alkali in (a). If the current is reversed, the whole arrangement will become transformed—the alkali will be found in (c) and the acid in (a).

It seems to me that the above experiment proves definitely that electrolysis *does* occur throughout the whole circuit instead of merely at the poles. The fact that the central dish (b) remains neutral, is no proof that no action takes place in its solution. It simply means that an active electrolysis has taken place throughout the whole length of the liquid circuit, so much so, that a complete transformation and rearrangement of atoms have taken place. All of the acid is found at (c); how did it get there except that it traversed the entire three dishes? How did all the alkali get to (a) except by the same process? (b) remained neutral because it was symmetrically placed between the two vessels, and as acid was passing through it in one direction sufficient alkali was forming in the opposite direction to keep its solution neutral. If the poles were placed in either ends of one long dish filled with a solution of litmus and sulphate of potash, and a strong current allowed to operate, the positive end of the dish will become acid in reaction and turn a deep red, the negative end will assume a deep blue color, while the center of the dish will remain neutral. Here we have electrolysis or an interchange of elements throughout the whole substance, but no disturbance is noticed until the poles are reached, when there

is nothing to satisfy the uncombined elements, and they bubble into the external air; hence the impression that electrolysis only occurs at the poles.

A simple experiment which illustrates well the action of electrolysis, as it seems to me it must occur in porous tissues of the body where the tissue current represents innumerable little compartments, is the following: A tube of glass is taken (Fig. 59), about one half inch in diameter, and to the two free ends corks are fitted, through each of which pass wires which protrude a quarter of an inch into the tube. One of the corks is placed in the tube and about it a solution of iodide of potassium is poured into the bottom of the tube so as to occupy about one inch of its length;



FIG. 59.

upon this is fitted a thin slice of raw potato about two m. m. in thickness, then more solution is turned in and another partition of potato is placed, and so on until the tube is filled with the solution and is divided into a number of compartments by the little partitions of potato. The tube is then placed horizontally in some convenient place where it can be watched undisturbed, and to the two terminal wires are attached the two poles of a galvanic battery, and the current is allowed to operate. The first effect noticed, is a liberation of gas at the negative wire pole and a gathering of iodine crystals at the positive pole. After the current has operated a little longer, the positive side of the potato partitions will begin to turn blue from the iodine of the solution which is liberated by electrolysis attacking the starch of the potato to form iodide of starch. The negative side is not immediately affected, and not until the current has operated for some time, does the whole thickness become tinted from the penetration of the grasping iodine. In time, a line of blue will appear in the liquid

upon the positive side, and if the current is allowed to operate long enough, this will gradually be communicated to the whole liquid.

In the above experiment occurs exactly the whole phenomena which must occur (judging from the nature of the factors we have to deal with) in the soft living tissues. If the vegetable partitions are objected to in the above experiment, animal membrane may be substituted by supplying each disk with a stiff rubber margin, and by filling the different compartments, five in number, with solution of litmus with the addition of sulphate of soda in one, as in Davy's experiment. Here, after the current has operated for a time, the fluid in the two compartments in the positive end will be found strongly acid, that of the two in the negative end strongly alkaline, and that of the center neutral, as was the case in Davy's experiment.

Davy proved, by employing two of his fingers as electrodes, each being attached to a pole of the battery, that the same phenomena occurred around their surface as though the electrodes were of metal. And from the nature of things we could expect nothing else.

\*Ingles Parsons passed a 200 m. a. current through a recently removed fibroid tumor of the uterus for about two hours, and that portion of it acted upon by the current cut quite hard and grisly as compared with the rest. This change was also perfectly apparent to the touch. Upon making microscopic sections, the portion of tissue in close proximity to the poles, was found devoid of structure, everything having disappeared except the fibrous tissue. While the tissue was changed at all points between the poles in Dr. Parsons' experiment, the greatest change was apparent at the poles because of the greater density of current at those points. We have seen in the chapter in which density of current was considered, how the current rapidly diverges between the poles in animal tissues.

\*Parsons, *British Gyn. Journal*, May, 1888, page 78.

The following experiment, by the author, demonstrates that the same effect will occur in the middle of the current between the poles, as at the poles themselves, if the same density can be maintained: A strip of fibroid tissue was carefully dissected out of a recently removed tumor of the uterus, about three m. m. in diameter and about twelve c. m. in length. Either end of this piece of tissue was attached by means of soft clay electrodes to the terminals of a strong galvanic battery (Fig. 60). A current of 100 m. a. was allowed to operate for thirty minutes. The effect upon the piece of flesh was almost identical throughout its

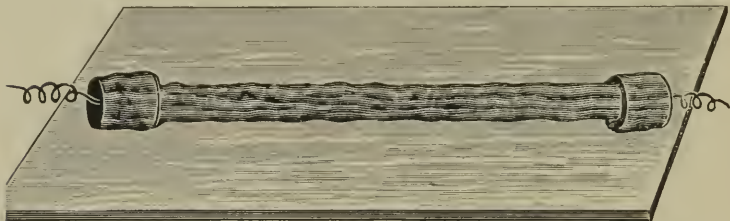


FIG. 60.

entire length. Soon after the current was turned on, the tissue slightly contracted in a longitudinal direction. Little drops of clear watery exudate appeared at short intervals throughout its length, upon its surface, and these were constantly changing and breaking from the escape of small bubbles of gas from the surface of the tissue. In the course of twenty minutes the tissue had become hardened and pale in color, and its resistance perceptibly increased. Examination of the tissue at the end of thirty minutes revealed the following phenomena: Tissue dry and contracted, and lighter in weight (this latter probably from loss of watery exudate which was left in perceptible quantity on the glass plate upon which the specimen rested). Upon examination with the microscope of cross sections from different portions of the tissue, but little variation in effect of the different portions was distinguishable. The muscular structure was destroyed, and in its

place, remained structureless tissue with small granular masses interposed, with an occasional minute globule of gas. The only difference in effect upon the two ends of the piece of flesh experimented with, was an excess of water exudate at the negative end. This simple experiment is easily performed, and it leaves but little doubt in the experimenter's mind that electrolytic action occurs throughout the entire length of an animal tissue circuit and is not confined alone to the electrodes which are only a portion of one complete circuit.

#### LOCAL EFFECTS OF POLES.

We have seen, however, that as the density of the current is increased the electrolytic action on a given area is increased. This peculiarity of the current is taken advantage of by the electro-therapeutist. The density of the current we know, is in direct proportion to the strength and inversely as the area of the electrode. If a small, good conducting electrode is placed upon a portion of animal tissue, a large indifferent electrode being employed to complete the circuit, an effect will be produced at the active electrode varying both with the polarity of the electrode and with the strength of the current.

**Positive electrode.** If the electrode is the positive one, we have seen that the acid portions of the electrolyte will manifest themselves by attacking the region of greatest density, viz., the small electrode. The effect upon the tissue of these acid *ions* is to produce coagulation of the albuminous particles in their immediate vicinity and thereby effect a hardness of those tissues. This characteristic action varies with the strength of the current from a slight congealing and hardening of the tissues in actual contact with the electrode, to a general coagulation and solidification of the tissues for a considerable space around the electrode.

**Negative electrode.** If the electrode is the negative one, the alkaline radicals of the electrolyte will manifest

themselves by attacking the region of greatest density—the electrode. The effect upon the tissues of these alkaline *ions* is a tendency to produce a solution of the tissues acted upon. This varies from a slight white eschar in direct contact with the pole, with a comparatively weak current, to a deep white cavity produced by a considerable destruction of tissue for a distance around the electrode.

\*Ciniselli was the first to describe fully the difference in character of these clots at the respective poles.

The cicatrices following the local application of the two poles vary as much as do the immediate effects and resemble cicatrices produced by concentrated acid, or alkali, respectively, except that the tissues are effected more deeply by the electricity. The positive cicatrix is hard and contracted, while the negative one is soft and uncontracted. These diametrically opposed local effects of the two poles Apostoli has made prominent and important features in his treatment of fibroid tumors of the uterus.

#### ELECTRICAL OSMOSIS.

The question of impregnating the living tissues with certain remedies in solution by means of the cataphoric action of the galvanic current is an important one.

The electrical conduction of iodine through the living tissues from one pole to the other, was advocated by Beer in 1869. This authority claimed that iodine could be driven directly through the tissues from the positive to the negative pole. When we realize the very great diffusion of the current between the poles in loose animal tissue, we can understand how often this experiment may prove a failure. Eulenberg, with his collaborators, Bruckner, Benedikt, Tiltzman, Fieber and Ossikowski found that it was not possible to conduct iodine for any considerable distance into the uninjured animal tissues.

That dissolved salts and certain drugs in solution,

\*Surgical Society of Paris, 1860.

can be introduced to the absorbents and the circulation so as to be absorbed and give rise to their physiological effects upon the general system, there is now no longer doubt. H. Munk, in his experiments, saturated sponges attached to either poles with the solution containing the drug with which he desired to impregnate the tissues. A current of considerable strength was employed which was repeatedly reversed. Strychnine by this method, was introduced into the system in considerable quantities in a few minutes. Quinine was found in the urine within a few hours and iodine in thirty minutes.

The author has repeatedly succeeded in getting marked physiological effects of muriate of cocaine, aconite and atropine by means of the cataphoric action of the constant current.

Much study has been given to this subject, and systems of therapeutics based upon its principles have been attempted.

#### SUMMARY.

1. Electrolysis of living tissues, is in direct proportion to the strength of the current and direct proportion to its density.

2. Electrolysis may occur at any or all the points in the line of the tissue circuit, as well as at the external poles.

3. Electrical osmosis, or the cataphoric action of the galvanic current, causes a direct transference of the fluids of the body through the tissues in a direction from the positive to the negative pole.

4. The products of interstitial electrolysis of living tissues, are removed by the absorbents of the tissue in which the action occurs.

5. When a portion of living tissue becomes overcharged with fluids from the effect of electrical osmosis, it is unloaded by the absorbents of the part acted upon.

6. The polar effect of an electrode upon the living

tissue with a concentrated electrode, varies with the polarity as well as the strength of the current.

7. The *kathode* acts locally like the varying effects of an alkali of different strengths, from (a) a slight burning with accompanying redness of the parts, with a mild current, (b) a more decided burning sensation with a local destruction of the superficial tissue, leaving a white scar, with a medium current, to (c) a severe burning pain accompanied with an active and deep destruction of tissues, a perceptible gathering of liquid products, and an active escape of gases through the fluids, with a strong concentrated current.

8. The *anode* acts locally like the varying effects of a deep penetrating acid of different degrees of concentration, from (a), a slight feeling of discomfort with a local redness of the tissues, with a mild current, with (b), a decided feeling of discomfort, a tendency to numbness, and a superficial hardening of the portion of tissue in contact with the electrode, with a medium current, to (c), a severe local pain, accompanied with numbness, and an effect of coagulation and hardening of the tissues for some considerable distance around the electrode, with a strong concentrated current

#### CATALYSIS.

\*Catalysis is a term employed by some writers to explain some of the mysterious phenomena which occur in living tissues from the effects of electricity in any form. We are aware that tissue changes are produced, that nutrition is promoted, that obscure nervous tendencies are transformed by the mildest application of the faradic, static, or galvanic form of electricity. We are aware too, that these effects cannot be attributed to electrolytic action, because the static and faradic currents as applied in medicine, have no electrolytic action. These effects of the current, then, including the refreshing and invigorating effect often experienced

\*Ziemssen, hand book of general Therapeutics.

from the application of the above forms of electricity, which cannot be the effects of electrolysis, but which may be due to the mechanical effects of the current, which, like massage or other form of mechanical treatment, favors tissue changes, are included under the convenient name catalysis, a term which it is hoped may rapidly become obsolete with many other terms connected with empiricism.

## CHAPTER XVI.

### APOSTOLI'S TREATMENT OF FIBROIDS.

Principles laid down by Dr. George Apostoli for the treatment of fibroid tumors of the uterus are unique and enduring. They may be added to, pruned and cultivated, but like the principles of Morse and Fulton they will be magnified into enduring monuments to the genius that first formulated and demonstrated them.

New fields were not explored in order to accomplish Apostoli's work. The utilization of already well-known facts by his genius, resulted in new principles which have an almost infinite range of application.

By means of an original apparatus he made possible the utilization of strong currents of galvanism through the human body in a manner that eliminated pain. This enabled him to demonstrate, beyond doubt, the principles that (a) galvanism in given doses would produce the rapid absorption of certain pathological growths, and (b) that the diametrically opposite effects produced locally at the two poles were capable of a variety of important practical applications.

Apostoli soon found that electricity to be employed as a worthy therapeutic agent should no longer be treated as a plaything, and in order to utilize its valuable principles, he insisted that physicians should adopt a means of measuring the strength of its current.

#### STRONG DOSES.

Dr. Apostoli made painless, large doses of galvanism, by adopting electrodes, for the poles which came in con-

tact with the sensitive skin, which would equally diffuse the current over a large surface. This was accomplished by means of molding a mass of potter's clay, the consistency of putty, over the surface through which the current was to pass, and attaching to it, by means of a metal plate buried in its outer surface, the pole of the battery. These electrodes were afterwards improved and made permanent by inclosing the molded clay in layers of cheese-cloth and insulating its external surface with sheet rubber.

#### EFFECT OF THE POLES.

Upon employing highly concentrated doses, with a metal uterine sound, as one pole, lying in contact with the uterine mucous membrane, he found the effect to be that of a caustic, which differed widely, according to the poles. Thus the local effect of the positive pole proved to be that of a caustic acid, while that of the negative was that of a caustic alkali.

While the chemical fact illustrated was not new, the application of this fact to local therapeutics was a discovery of great value. It was soon shown by this experimenter that the positive pole, because of its peculiar action, possessed a marked hæmostatic effect, while the negative pole could be utilized in destroying small granulations, vegetations, etc.

Thus we find a system of treatment formulated by Dr. Apostoli based upon well-known laws of electricity. The principles sought out by him are so well crystallized into one compact method that they will, without doubt, constitute the basis of all other departures for treating fibroids of the uterus and many other local difficulties, for the whole future. For this reason I desire to make clear his principles and his method.

The battery used by Dr. Apostoli is one that has an electromotive force of from 50 to 75 volts. It is composed of a series of Leclanche cells connected with a selective switch-

board which renders it possible to utilize any number of cells from 1 to 50. The two electrodes employed in all operations are connected with either pole of the battery. A milliamperere meter of the Gaiffé pattern, which registers at least 300 ma., is included in the circuit. The electrodes are of two varieties. (1) The passive electrode, (2) the active electrode. The passive or cutaneous electrode is composed of potter's clay, as before stated.

The active electrodes are two in number. One is fashioned after an ordinary uterine sound and is for application in the uterine canal. It is constructed of unattackable metal, as platinum or irridium. This sound is attached by means of a conducting cord, with one pole of the battery. A muff of celluloid tubing insulates the vaginal portion of the sound from the surrounding tissues. The other electrode is also manufactured from unattackable metal. It is similar in size and shape to the other except that instead of terminating in a bulbous point it ends in a spear shaped point. This electrode is for the purpose of penetrating a presenting portion of the uterus or tumor when it is impossible to treat the case from the uterine canal. This is accomplished by thrusting this sharpened sound, for a short distance, into the presenting part and insulating the vaginal portion as with the other electrode.

The distinct operations employed by Dr. Apostoli are four in number:

1. The galvano-caustique positive.
2. The galvano-caustique negative.
3. The galvano puncture negative.
4. The galvano-caustique positive and negative.

The galvano-caustique positive, is employed primarily for the purpose of checking hemorrhages from the uterine canal. The internal active electrode, which is fashioned after an uterine sound, is made to conform to the uterine canal, and being properly insulated with the celluloid muff to the cervical point, is attached to the positive pole. After

the abdominal surface electrode is applied, and the connections made secure, a current of sufficient intensity is turned on to produce active cauterization at the surface in contact with the internal electrode. The effect of this pole, as we have seen, is to produce active coagulation and hardening of the tissue with which it comes in contact, because of its acid cautery effect. It is this peculiar property, therefore, which has the remarkable advantage of checking hæmorrhage in hæmorrhagic fibroids.

The second operation, the galvano-caustique negative, is employed for the purpose of enlarging the uterine canal and for the rapid reduction of the tumor where hæmorrhage does not exist. The same internal active electrode, introduced with the same precaution, and with the same care for proper insulation, is attached to the negative pole of the battery. The abdominal electrode of clay is applied, the connections made secure and a current of sufficient strength turned on to cause active liquefaction at the point of contact with the internal electrode. We have seen that the liquefaction at the negative pole is caused by its alkaline tendency which makes it resemble the action of caustic alkali when powerfully concentrated. The influence of the negative pole makes it of great value in reducing the size of the tumor, and it is always employed when a hæmorrhagic condition does not demand the coagulating effect of the positive pole.

The third procedure, the galvano-puncture negative, is employed in tumors of the uterus where it is impossible or impracticable to treat the cause by means of the intra-uterine electrode. The galvano puncture is accomplished by thrusting the point of the spear electrode into the presenting uterus in the vagina, in as close proximity to the cervix as practicable and in the direction of the greater mass of the tumor. The depth of the thrust should not be more than two centimetres, or one-third of an inch. After the electrode has been placed the insulating celluloid muff should

be carefully adjusted and the abdominal electrode being properly applied a current of from 100 to 250 ma. should be turned on, the negative pole being always employed. This operation has a decided influence in reducing the size of the uterus.

The fourth procedure is the mixed operation of treating a case by galvano-caustique negative and positive at successive seances. This is employed where it is desirable to reduce as rapidly as possible a large hæmorrhagic tumor and at the same time control the hæmorrhage. It is desirable, according to Dr. Apostoli, when rapid reduction in size is sought, to employ, as frequently as practicable, the galvano-caustique negative, but if the case is of a hæmorrhagic character it is impossible to do so exclusively. Under such circumstances the galvano-caustique negative should be used early in the month, immediately following the regular menstrual period, when there is least tendency for hæmorrhage to occur; the galvano-caustique positive being reserved for the latter part of the month, in order to lessen the tendency to hæmorrhage at the approaching menstruation.

The strength of current employed by Dr. Apostoli varies from 50 to 250 ma.

## CHAPTER XVII.

### AUTHOR'S MODIFICATIONS OF APOSTOLI'S TREATMENT OF FIBROIDS—EXACT DOSAGE.

In considering the Apostoli method it must have been noticed that nothing was said about varying doses for different cases possessing tumors of different dimensions. We have frequently met with cases where the tumor, measured by the uterine canal, several inches, in which the symptoms were no more aggravated than in another tumor which measured not more than one-third the size. Here are two tumors. Shall we give them each 200 milliamperes? Not if we expect to get the same local effect in each. In the smaller tumor the local effect of the active electrode with a 200 ma. current would be three times as active on any given portion of its interior as on any portion of the larger tumor. For this reason, if we are to do uniform work, we must vary our doses, and know the capacity of our active electrodes. In other words, we must be able regulate the density of our current as well as its amperage.

In considering density we observed that the lines of force of a given current varied in an inverse ratio with the size of the conductor. For example: if I press a metal electrode with an area of one sq. cm. upon the skin of my hand, and turn on a galvanic current of 10 ma. for five minutes and I find at the end of such time that the skin is deeply cauterized, by continuing the experiment, I will find that a current of 20 ma. will be required to operate for five minutes in order to cauterize with the same intensity a surface of 2 sq. cm. On the same basis it will require double

the current in amperage to cauterize to the same degree the endometrium of a fibroid uterus 4 inches in depth that is required in one of 2 inches in depth. The second electrode, in each of the above experiments doubled the area of the conductor to the tissues, hence scattered the lines of force, therefore to have the lines of force as dense as in the first experiment, in each case double the amperage was necessary.

Early in my work with electricity in fibroids of the uterus, I was driven to take cognizance of this well-known law of density. In my article on *The Treatment of Fibroids of the Uterus by Galvanism*, read at the International Congress at Washington in 1887, I called the attention of the profession to this fact, and gave the result of my experiments, from which I established a basis of exact dosage. The electrodes which I then employed and the basis on which I made my calculations I have found after five years of practical work to represent approximately the truth. I have also had the satisfaction of seeing the same principles incorporated in electrodes devised by the most skillful in this kind of work. I will, therefore, quote from the article referred to: "Experimenting, I have found that a current of 25 ma. traversing a positive platinum electrode of one sq. cm. surface forced firmly against the mucous membrane of an hypertrophied cervix uteri, the circuit being completed by a large abdominal electrode, will produce a dry condensed condition of tissue beneath the surface of the plate, in five minutes.

"This surface can be penetrated with a lance to the depth of one and a half mm. without producing the slightest tendency to hæmorrhage, and the tissues are denser than normal still some distance further below the surface. Granting that the condition obtained in this experiment is what is sought, in cases of hæmorrhagic fibroids, throughout the whole surface of the mucous membrane of the uterus, in order to prevent subsequent hæmorrhage, we can recog-

nize a basis in the experiment from which we can construct a table of exact dosage so far as the treatment of the hæmorrhagic element is concerned. For by carrying our experiment still farther it is found that a current of 50 ma., or just double the strength of the current required in the former experiment, is necessary to produce, in the same time, the same effect when the surface area is just double or 2 sq. cm. If, therefore, for example, we have an uterine canal that is 10 cm. in depth, and the electrode filling the canal has a surface of one sq. cm. to each cm. in length we would have 10 sq. cm. of active surface in contact with the tissues; this, therefore, figured upon the same basis, would call for a current of 250 ma. for five minutes, in order to get the characteristic effects necessary to check hæmorrhage from the whole surface. Or, the uterine canal that would require an Apostoli electrode 20 cm. in length (and this depth is not infrequently met with) would require a current, if the electrode was 4 mm. in diameter, and if equal conduction took place from its entire surface of over 600 ma. strength. This strength of current would not be tolerated except in very exceptional cases, and if it were, there is no means of being certain that the sound comes in accurate contact with the mucous membrane in its entire extent. There is some doubt, too, that a surface so large, even if it were in accurate contact would conduct equally from its entire area; the consequences therefore, in this case would be, excessive cauterization and subsequent suppuration of portions of the mucous membrane and little effect, if any, on the other portions. It is this uncertainty of result and painfulness of application that I have succeeded in overcoming. This is accomplished by adopting a means by which the whole mucous membrane of a hæmorrhagic uterus can be successfully treated in a number of seances by attacking successively different portions of it until the whole area has been covered.

“To accomplish my object I have had constructed pecu-

liar internal electrodes (Fig. 61). I have confined myself so far, to two sizes; one with an active surface of 2 sq. cm., the other of 4 sq. cm. The first to be worked with a current of

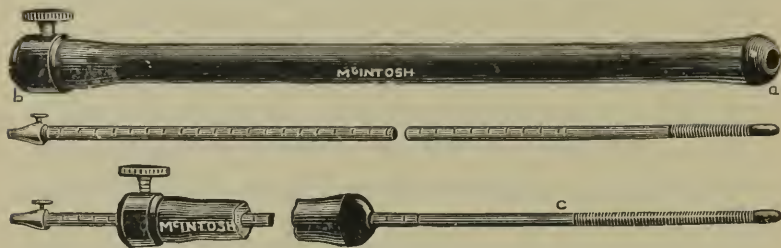


FIG. 61.

50 ma., the second with a current of 100 ma. The metal that constituted the active surface of these electrodes is platinum wire in spiral wound over soft copper wire of the required diameter. The portion of the instrument is connected with the handle of the electrode where it receives its attachment to the battery, by means of an extension of the copper wire core incased in a smooth insulating sheath. The insulated portion, with its insulation, is of the same diameter as the platinum part of the sound, and is therefore small enough to enter the uterine canal. Upon the distal end of the platinum portion is a screw attachment to which a small hard rubber tip is attached. This tip is bulbous and from its shape and material will readily follow the canal."

"I have confined myself to two diameters. (Diameters of any size, of course, may be constructed. The operator, however, must see to it that the instrument-maker is correct in his mathematics.) Those used by me are of 3 and 5 mm. in diameter, and are respectively called No. 3 and No. 5. Of each of these two diameters, as I have stated, I have had two electrodes constructed: One of 4 sq. cm. surface, the other of 2 sq. cm. metal surface. Of course the length these active surfaces occupy on the different electrodes, depends upon the diameter of the particular instrument. If the diameter is three millimeters,

the 4 sq. cm. will occupy about 45 mm. in length of the instrument; if it is 5 mm. in diameter the same surface, 4 sq. cm., will occupy about 26 mm. in length of the instrument. In ordering, then, one of these electrodes, from the instrument-maker, the diameter of the instrument and the strength of the current to be used should be stated. Thus, if an electrode is required of 3 mm. in diameter and the current to be employed with it is 100 ma., simply order a  $\frac{3}{100}$  electrode; if a 100 ma. current is too high, order a  $\frac{3}{50}$ , which will indicate an electrode 3 mm. in diameter with a surface which will require, to check hæmorrhage, a 50 ma. current."

By this time it must have become apparent to the reader that the above electrodes are especially useful in controlling that distressing symptom of fibroids of the uterus—hæmorrhage. It must also have become apparent, that, with the above electrodes but a definite strength of current is admissible with an electrode of a definite size. With the electrode of 4 sq. cm. for example, 100 ma. should constitute the maximum dose. If the electrode of 4 sq. cm. does not cover the entire endometrium at one sitting, the distal end of the canal should be attacked first, and at the next sitting the remaining portion, or as much of it as possible, and if any portion of it is still left, it should be treated in its turn, and so on until all portions of the long canal have been successively attacked and cauterized. Thus a 100 ma. current will accomplish accurately in three sittings and with a comparatively painless dose, the same work, which if done at one sitting with an ordinary sound, would require the large and certainly painful dose of 300 ma.

I have dwelt upon this point at the risk of becoming tiresome, because I am convinced that my work has been much more satisfactory and accurate, since the necessity for regulating the dosage has been recognized, and since I have supplied myself with tools which carry out the idea involved.

## FLEXIBLE ELECTRODES.

The author in the construction of the above electrodes, incorporating the principle of exact dosage, had another minor aim in view, viz., flexibility. The electrodes described are as flexible as the ordinary English urethral bougie; owing to this fact they will traverse any canal, no matter how tortuous, and on account of their perfect pliability are liable to produce the minimum amount of traumatism. I am sure, by means of these instruments, one can apply galvanism to the endometrium in a third more cases than can be treated by means of the solid platinum sound, or any form of carbon electrodes—thus obviating the more disagreeable alternative of vaginal puncture for a proportionate number of cases.

## OTHER ELECTRODES.

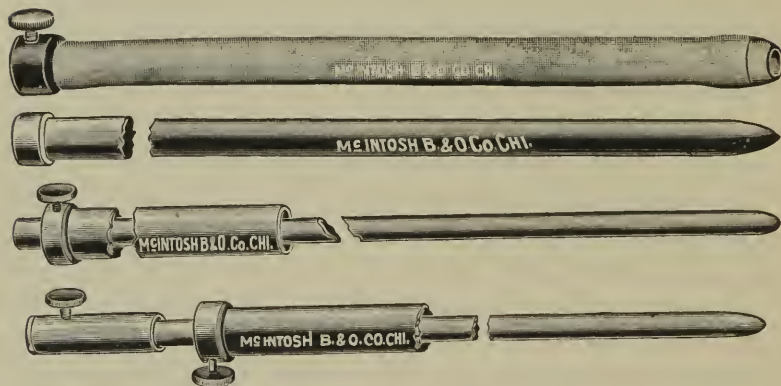


FIG. 62. AUTHOR'S BLOCK TIN ELECTRODES.

For intra-uterine electrodes, when the positive intra-uterine pole is not indicated, or when one of the flexible electrodes is not required, I employ electrodes constructed of block tin. (Fig. 62.) These, of course, cannot be employed for the positive pole because of the corroding effects of the *ions*, which collect at that pole, when in use on the tissues of the body. I have constructed these electrodes in sets of three, with diameters of 3, 4 and 5 mm. respectively.

An insulating muff of soft rubber tubing is employed to protect the vagina. The points are slightly rounded and bulbous to facilitate their introduction. The ad-



FIG. 63.

vantage of these electrodes over platinum is their cheapness, perfect pliability and lightness. For the positive pole when any but the concentration or flexible electrode is required, I use an ordinary Apostoli platinum sound (Fig. 63), or one of the following:

#### DR. APOSTOLI'S CARBON ELECTRODES.

The intra-uterine electrodes of carbon were introduced by Dr. Apostoli for the double purpose of more accurate concentration, and the advantage of an unattackable substance of comparative cheapness for the construction of electrodes of large diameter. Carbon electrodes are inexpensive, are unattackable by the positive ions, and can readily be made of any required diameter. Like my own concentration electrodes, they can only be employed to treat a portion of the endometrium at a given time, and successive sittings are required to cover a large canal. These electrodes are constructed of different diameters from that of a slate pencil to the diameter of an inch or more. Dr. Goelet, once stated in a discussion, that he had seen Dr. Apostoli use an electrode of carbon the size of an orange. This is larger than I have ever employed, although I can conceive of cases in which such an one might be indicated. In the treatment of fibroids for hæmorrhage, it is necessary to cover the endometrium accurately, and an electrode must be employed of a diameter proportionate to the size of the uterine cavity. For that reason it frequently becomes necessary to dilate the cervical canal, which is often smaller than the remaining portion of the uterine canal, before the proper electrode can be inserted.

## ABDOMINAL ELECTRODES.

For a passive electrode, clay answers nearly every demand. It is readily obtainable, is economical, and when properly mixed and moulded conforms easily to all irregularities of the surface of the body and diffuses the current perfectly. The minor objections which may be mentioned are: the difficulty of regulating temperature and the uncleanliness of the wet clay. In Dispensary work I employ a clay electrode covered upon its active surface with thin layers of cheese-cloth, and upon the external, inactive surface with sheet rubber. The two are carefully stitched

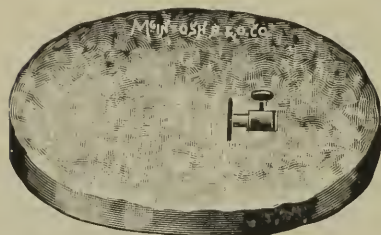


FIG. 64.

together around the edge of the electrode. A metal plate with a binding post attached, is buried in the clay beneath the rubber with proper attachments for battery cord. (Fig. 64.) These electrodes are now in stock at nearly all instrument-

makers. If they become hard they should be soaked in warm water for some time before using.

For office work the author invented, some years ago, his membranous electrode, which recommends itself because of its cleanliness and elegance. (Fig. 65.) Over the concavity of a concavo-convex disc (a) of soft metal of appropriate dimensions, is loosely stretched an animal membrane (c) which is so securely fastened to its circumference as to render the interspace water tight. Between the concavity of the disc and the membrane is left a space (b), one and one half inches in thickness, which is filled

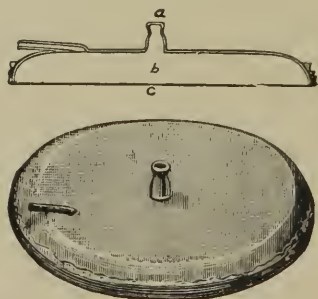


FIG. 65.

with warm water or a warm solution of salt. The electrode is filled through a stopper on the metal surface and the connections are also made from this surface. This electrode is applied to the surface of the body, so that the membranous surface is in contact with the skin. It adapts itself accurately to all irregularities, covers a large surface (400 to 800 sq. cm.) and causes a diffusion of the current so perfectly that it makes a very elegant and perfect substitute for the Apostoli original clay electrode.

#### VARIETY OF FIBROIDS.

We have now reached a point in the history of the treatment of Fibroids by electricity, at which we are obliged to discriminate, because we have learned by experience, that all tumors of this kind are not equally benefitted by the treatment. The term Fibroid of the uterus covers fibrous enlargements of the uterus, and myomatous enlargements of the uterus, both of a benign nature. A tumor of the uterus containing a predominance of fibrous material of a non-muscular nature is called a fibroma and is usually designated as a "hard fibroid." One containing a predominance of muscular material is called a myoma and is distinguished as a "soft fibroid." Those containing approximately an equal development of both fibrous and myomatous material are naturally called fibro-myomas. To this latter class belong a large percentage of all fibroids.

#### CLASSIFICATION AS TO SITUATION.

My experience with these growths leads me to divide them according to situation into the four following varieties, with their relative percentage of occurrence: (1) Interstitial, 55 per cent. (2) Sub-peritoneal, 20 per cent. (3) Intramural, 15 per cent. (4) Sub-mucous, 10 per cent.

**An interstitial fibroid** is one in which the new growth of tissue is uniformly distributed throughout the walls of the uterus without any distinct neuclei of development.

**An intramural fibroid** is one in which the new growth

is situated in the middle of some part of the wall of the uterus but has one or more neuclei of separation and distinct development.

A **sub-peritoneal fibroid** is one which grows from one or more centers of development and projects, more or less, from the wall of the uterus into the peritoneal cavity.

A **sub-mucous fibroid** is one which grows from one or more centers of development and projects from the wall of the uterus into its cavity. Sub-peritoneal or sub-mucous fibroids may become polypoid.

I make the unusual distinction between interstitial and intramural fibroids for therapeutic reasons, since their action under the influence of either ergot or electricity is strikingly different.

#### CLASSIFICATION ACCORDING TO SYMPTOMS.

One of the most characteristic symptoms of fibroids of the uterus is excessive uterine hæmorrhage, at or between menstruations. Occasionally, for certain good reasons, increased hæmorrhage does not exist with these tumors, therefore we speak of them as *Hæmorrhagic and non-Hæmorrhagic* fibroids.

**Hæmorrhagic** fibroids may be found under any form of the four varieties of classification given above, but they are most marked and enduring with the interstitial, the intramural and the sub-mucous, and least liable to occur in the subperitoneal variety. Fully 75 per cent. of all fibroids of the uterus are hæmorrhagic.

**Non-Hæmorrhagic** fibroids are usually found in cases of the sub-peritoneal variety where the development is polypoid, or of such a character that the extent of the uterine mucous membrane is not materially increased. However, occasionally non-hæmorrhagic fibroids will be found in any of the four varieties. In the submucous fibroid the hæmorrhage will frequently cease for a considerable time, following an expulsion of one or more centers of development, only to reappear later from new centers of development.

## EFFECTS OF CURRENT UTILIZED IN TREATMENT OF FIBROID TUMORS.

1. Local effect of the negative pole.
2. Local effects of the positive pole.
3. The polar and inter-polar electrolytic effect of galvanism.
4. The calorific effect of the current.
5. The action of the galvanic current in causing contraction of the uterine muscular fibers.

## GENERAL REMARKS.

In all cases of fibroids of the non-hæmorrhagic variety the intra-uterine electrode used should be negative. The current employed should be as strong as the patient can endure without pain, up to a dose of 25 ma. for each sq. cm. of internal concentration; beyond that point of strength it is liable to cause destructive cauterization.

There is not much danger, however, of exceeding the safe limit if the block tin electrode, applied to the whole surface of the canal, is employed. Approximately one can estimate the strength which is safely admissible with such an electrode, as 100 ma. for each inch in depth of the uterine canal. As from 200 to 300 ma. is about the maximum dose tolerated in ordinary cases, it can readily be seen that there is not much danger of over-cauterization with the sound electrode, because any uterine canal of a fibroid uterus must be at least three inches in depth. Therefore, in non-hæmorrhagic fibroids employ the maximum strength of current which will be tolerated with the ordinary non-concentrated electrode of platinum, or block tin, applied to the whole length of the uterine cavity.

In cases of hæmorrhagic fibroids it is desirable to so concentrate the current at the positive intra-uterine pole that there will be 25 ma. for each sq. cm. of such surface. It should not exceed this relative strength, and on the other hand, such strength is actually essential to prompt success. I have, however, already dwelt at length upon this point in describing the special concentration electrodes.

## TECHNIQUE OF THE TREATMENT.

When it has been ascertained that a given case is suitable for Apostoli's treatment, I carefully instruct the patient how to use a vaginal douche of 1-10,000 bichloride of mercury solution, in order to render that cavity aseptic. I then insist that this routine be carried out before the patient visits me for treatment. Private patients can be trusted in this matter, and no application should be given unless such precautions have been observed immediately preceding the time of treatment.

Intra-uterine instruments employed should be rendered aseptic with the same care that is exercised in preparing for a laparotomy or for curetting a puerperal uterus. This is imperative.

**A Typical Non-Hæmorrhagic Case.** While such cases are rare, occasionally we meet with non-hæmorrhagic fibroids. The patient is instructed to wear loose clothes, or is allowed to loosen her clothing before taking her place upon the table. The latter should be an ordinary gynæcological chair or table with stirrups and a horizontal bed. The patient lies on her back, with buttocks drawn well to the end of the table, and her feet supported by the stirrups. A block tin or platinum electrode, of the diameter considered suitable to fill the uterine canal, is selected and carefully passed to the bottom of the uterine cavity. If the sound does not readily pass, information as to the conformity of the canal can often be obtained by first passing a bulbous pointed flexible urethral bougie, after which, from the knowledge gained, the sound can be successfully directed. A speculum is scarcely ever necessary for this work. When this electrode is properly adjusted the vagina is insulated from the sound by pushing the rubber insulating muff well against the cervix, and the electrode is carefully attached to the negative pole of the battery. The abdominal electrode, of clay, or the membranous electrode, is now passed under the clothing, molded in its place on the abdomen

and securely attached to the positive pole. It is of course taken for granted that a discreet operator has carefully tested his apparatus before proceeding with his treatment, as he would examine his instruments before performing a delicate surgical operation. Each are equally essential.

Being satisfied that the battery is all right, and having again carefully examined the connections, the operator slowly turns on the current, watching alternately the face of the patient and the milliamperere meter, until the patient complains of discomfort, or the meter marks a suitable dose. If the complaint is made before a dose is reached, many times, by waiting a few seconds, she will easily tolerate the required increase. In nothing is patience more required than in this work. The current should be allowed to work for five minutes at its maximum strength, when it should be gradually turned off, the electrodes removed, and the patient requested to rest for some time (5 minutes to an hour) before attempting to walk. Weak patients are, of course, treated at hospitals, or at their homes, and are expected to remain quiet much longer. Ordinarily no pain follows this application; occasionally, however, some is experienced, but rarely is it severe. Some patients are stimulated by the treatment, and are impelled to over-tax themselves, while others are temporarily exhausted and subsequently exhilarated. On the whole, it almost invariably acts as a powerful general tonic.

**A Typical Hæmorrhagic case.** An interstitial fibroid of oval contour, 4 by 8 inches in diameter, distributed equally in the walls of the uterus, so as to make it resemble a pregnant uterus at five months' gestation, and enlarging the whole organ so that the canal is lengthened from the normal to five or six inches in depth, with a history of excessive and prolonged hæmorrhage at menstruation should be treated in the following manner: The uterine canal should be measured as accurately as possible, both as to length and diameter. Should it be of such a depth that its

whole surface cannot be properly acted upon at one sitting, by the dose which the patient can tolerate, it will be necessary to select an electrode which will cauterize a portion of it at a time. If we find that the canal will be well filled by an electrode 3 mm. in diameter, we select one of an active surface of 4 sq. cm., requiring a current of 100 ma. to cause sufficient action upon the endometrium over that active area to check tendency to hæmorrhage. After carefully preparing the patient, and apparatus, this electrode is inserted to the bottom of the uterine cavity, so that its active and distal end will come in contact with the distal end of the uterine canal. The electrode is then attached to the positive pole, the abdominal electrode is carefully adjusted and attached to the negative pole, and the current is gradually turned on until 100 ma. are registered. At this point it is held for five minutes when it is gradually turned off, the electrodes removed, and the operation completed. This causes a cauterization of the distal end of the uterine canal, corresponding in area to the active surface of the electrode—4 sq. cm.—of sufficient intensity to seal up its vessels. The next day the same electrode should be inserted so that it will cauterize a second portion of the endometrium, and so on until the whole has been attacked and cauterized. With an electrode the size of the one described and a canal five to six inches in depth, three sittings would be required, of 100 ma. each, to accomplish a single cauterization. As different portions of the canal are operated on each day the applications can be given as frequently as once a day. If a patient will tolerate a 200 ma. current, double the surface may be operated upon by employing an electrode of 8 sq. cm. surface. However, I have obtained the best results from small electrodes. When a large surface is exposed, the unequal conduction is such that certain portions are over cauterized while others are neglected, and the work is not satisfactory.

When the internal electrode is withdrawn, at the end

of each application, the depth of the uterine canal should be noted, and this together with the diameter of the electrode employed recorded on the record of the case for each particular day.

Oftentimes one of the most difficult parts of the operation, owing to the distortion of the canal, is the introduction of the electrode. I have been obliged in a number of cases, to postpone treatment from day to day for a number of days, on account of being unable properly to adjust the electrode in the uterine canal. I have seldom found a case, however, if the cervix was within reach at all, in which, after more or less persistence, I have not been rewarded finally by being able to traverse the canal with the flexible electrodes which I have described. After once accomplishing an entrance and learning the peculiarities of any particular case the future introduction of the electrode becomes an easy matter.

**Ordinary Cases.** We very frequently find cases of fibroids in which, while hæmorrhage is severe for a short time at menstruation, it is not usually prolonged. These cases should be treated with both the negative and positive intra-uterine electrodes. It is advisable to employ the negative as frequently as possible, because of the more rapid changes produced by that pole. At the same time the tendency to hæmorrhage must not be utterly disregarded. Cases that will not bear exclusive use of the negative pole, therefore, should be re-enforced previous to each menstrual period by a few treatments with the positive pole. I usually employ the ordinary block tin or platinum electrode for the negative pole, commencing immediately following menstruation and continuing until within a week of the second menstrual time, when I seek to cover the whole endometrium with the positive pole, properly concentrated, before the flow appears.

By this simple procedure, if the case is not of an excessively hæmorrhagic nature, I get the benefit of the

negative pole for two thirds of the month without running the risk of hæmorrhage.

A few cases will be found in which the uterine canal is of large diameter after passing the cervix, and at the same time smooth and capable of treatment if the cervix can be passed. These cases should be anesthetized, if necessary, and the cervical canal dilated in order to gain uniformity of the canal and to allow the passage of an electrode of necessary diameter. In these cases the large carbon electrodes of Apostoli should be employed. The same attention to dosage can be maintained with the use of these as with my own concentration electrodes, if care is taken to estimate their active area.

**Electro-Puncture for Fibroids.** This operation should not be practiced by any but well-trained surgical gynecologists. It should not be performed through the abdominal walls. The puncture should only be made from the vagina directly into the uterine tissues affected. The puncture should be shallow—not more than two centimeters, frequently less—and the strictest aseptic details should be observed. It should never be employed if it is possible to treat the tumor from the uterine canal. *Finally, it should never be resorted to except in otherwise hopeless cases, cases in which the Battey-Tait operation, or hysterectomy do not offer an average chance of success in the hands of expert operators.* In the light of our present knowledge, after seven years of enthusiastic work with electricity, a strict surgical conscience will not allow me to vary the above opinion one iota.

**Puncture Electrodes for Fibroids.** Dr. Apostoli employs a steel or platinum needle or sharp-pointed probe through a celluloid canula. The canula is used as a guard and an insulator—as a guard to regulate the depth of the needle, as an insulator to protect the walls of the vagina from the metal staff.

The author uses a platinum-pointed needle two mm. in

diameter with a trochar point. About five inches from the point is a shoulder which limits the depth of the puncture by being arrested by the canula or insulating shield. This shield is a small glass tube 5 mm. in diameter of the required length. I prefer glass to celluloid because it is easier to keep clean. It is well to have two shields: One allowing the needle to penetrate the tissue 1 cm., and one allowing it to penetrate 2 cm. On the proximal end of the staff of the electrode should be fitted a properly insulating handle. Fig. 66 shows the author's electrode without glass shield.



FIG. 66.

The negative pole, as a matter of choice, is selected for electro puncture. It has a reputation of being a rapid promoter of absorption, and its local effect is such that it establishes a drainage channel for its products which are abundant in watery constituents. Thus while the inter-polar effect would be identical with either pole as the active factor, for the above reasons the negative pole is ordinarily employed for the puncture electrode.

**The Operation.** Surgical cleanliness is imperative. The patient should be given treatment where rest for at least an hour, in a recumbent position, can be obtained. I refuse to administer this treatment where I cannot have the patient under perfect control, either at the patient's house or at a hospital. Immediately before the operation, then, the patient should have a thorough antiseptic vaginal douche. After she has been placed upon the operating chair or table, as in preparation for the ordinary intra-uterine treatment, a digital examination should be made and a point selected upon the vaginal portion of the tumor on which there are no pulsating vessels. Along the palmer surface of the finger the glass canula is directed and its

distal end pressed against the point selected for puncture. While the canula is firmly held in position the needle is passed into it and thrust into the tissues until it is arrested by its shoulder, the depth of the puncture depending entirely upon the length of the canula. To this electrode is now connected the negative pole of the battery. An abdominal electrode is adjusted and attached to the positive pole. The current is then gradually turned on until the limit of toleration of the patient is reached, if she is not under an anæsthetic, or if anæsthetized a maximum dose of 250 ma., and allowed to operate from 5 to 8 minutes. It should then be gradually turned off and the electrodes removed. The vagina should be loosely filled with iodoform gauze, and the patient instructed to remain in the recumbent position. The next day the gauze may be removed and a thorough antiseptic vaginal douche employed daily for several subsequent days. The operation should not be performed oftener than once a week; an interval of ten days being about the proper average, while it may be advantageously utilized as seldom as once in a month. Unless, for some reason, a very strong dose is desirable, or the patient in question is unusually sensitive and unmanageable, a general anæsthetic is not required for this operation. I have employed with some degree of success, cocaine and carbolic acid, applied several minutes before the operation on a pledget of cotton.

There is scarcely ever any hæmorrhage following this operation. I once had quite a little burst of venous hæmorrhage, which was immediately checked by the pressure of the iodoform packing. The puncture is so shallow that should one be so unfortunate as to wound a small artery, means of stopping the hæmorrhage could be easily found. Some operators have suggested reinserting the electrode into the wound and attaching it to the positive pole of the battery and employing a current sufficient to effectually coagulate the blood and produce hæmostasis.

## CHAPTER XVIII.

### REPORT OF CASES—SUCCESSFUL.

The following report of cases includes but a few of the very large number which I have treated. These cases have been selected, not because they present anything unusual in the way of good results, for they do not, but because their authenticity cannot be questioned.

*Case 1. Interstitial fibroid, five inches in depth. Intrauterine negative and positive galvanism. Complete cure. Subsequent laparotomy proved the uterus to be absolutely normal.*

Miss A., age 28, was referred to me by Prof. W. H. Byford three years ago for galvanic treatment of a bleeding fibroid which measured five inches in depth. The uterus was partially retroverted and immovable. The hæmorrhage was confined to the menstrual periods, however, materially lengthening the duration and quantity of the flow, until the patient was extremely anæmic and weak. Besides hæmorrhage severe pain from pelvic pressure was complained of and the patient was completely bedridden. She had been under the care of the physician who sent her to me for many months and all medical treatment, including a systematic course of ergot, had been thoroughly pursued with a constant increase of symptoms.

The uterus measured five inches in depth and was a fair example of simple interstitial fibroid, developed uniformly throughout the tissues of the uterus, enlarging that organ to a smooth, oval regular mass, resembling a four and one-half months pregnancy. It was slightly retroverted, the axis occupying a line parallel with the axis of the body.

From repeated inflammatory attacks it had become adherent and immovable.

Treatment was at once begun at the Woman's Hospital. During the early portion of the month the platinum electrode, covering the entire length of the uterine canal, was employed as the negative pole. Treatments given every other day. The last of the month the whole canal was covered once, by means of my concentration electrode 5 mm. in diameter and a surface of four sq. cm.

The effect of this was to check excessive menstruation and at the same time rapidly reduce the tumor. The treatment was continued for about four months. The growth reduced rapidly in size, the hæmorrhage became less and less severe at menstruation, and when the treatment had been employed for three months, the inflammatory exudate surrounding the uterus had become so thoroughly absorbed, that the organ was freely movable. The treatment was continued until the uterus was near its normal size and could be retained by means of a Hodge-Smith pessary. At this time I requested the patient to return to Prof. Byford and ask his opinion on the advisability of shortening the round ligaments. He examined her and expressed complete surprise at her changed condition, recommending the operation for which she had sought advice. It was accordingly performed and since that time she has been perfectly free from the old symptoms.

In October, 1891, she again consulted me for a severe pain in her left side. Upon examination I found a small tumor about the size of an apple growing in the left ovarian region. Laparotomy was advised. In November, 1891, in the presence of the class of the Post-Graduate Medical School, assisted by Dr. Eibelberger, of Sioux City, Dr. L. M. Small, of this city, and the Woman's Hospital House Staff, I opened the abdomen and removed a small ovarian cyst. Upon inspection the uterus was absolutely normal in size. Its external diameters, as nearly as could be judged,

were three, by two, by one and one-half inches. It was held well forward by the round ligaments.

*Case 2.—Diagnosis: Bleeding, painful, myo-fibroma of the uterus. Treatment: Forty-four applications of galvanism. Result: Cure.*

Mrs. D., æt. 24, married two years, no children, no miscarriages. Puberty at 14. Menstruation irregular and profuse, lasting five or six days. Headaches severely at menstruation and severe neuralgic pains of the pelvis following. Bowels constipated, hæmorrhoids, leucorrhœa, frequent and painful urination. Local examination disclosed small vagina, large patulous cervix, with uterus large and canal taking the direction parallel with the axis of the body, and measuring 11 cm., or a trifle more than 4 inches in depth. With sound in uterus and by bimanual manipulation there could be distinguished a thickening of the anterior wall of the fundus. The uterus in the rectal-abdominal examination appeared at least double its natural size, smooth and regular in contour, with a disproportionately enlarged fundus. Dr. Arvid H. Wimermark assisted me in a few of the treatments given this case.

The first twelve treatments received by this patient were after the unmodified Apostoli method, without any attempt at accurate concentration, and a current varying from 100 to 200 ma. in strength. Six intra-uterine galvanic-negative treatments were given in the first fourteen days, followed by four galvanic-positive treatments, one for every second day, in order to modify the amount of the approaching menstruation. Following the first menstruation two more of these applications were made, when I adopted the method of internal concentration before referred to, using the 4 sq. cm. surface with a 100 ma. current. Thirty of these treatments were afterwards employed; twenty-two of the galvanic-negative and eight of the galvanic-positive. The whole time of treatment extended over three months, including three menstrual periods.

The effect of the treatment was markedly noticed in the behavior of the first menstruation, the flow having been modified in quantity, and without the slightest pain. The second menstruation lasted but two days, was very scanty and entirely free from pain. The third menstruation lasted three days, was free from any annoyance, and the flow small in quantity, with no pain. The depth of the uterus had not markedly decreased, but was smaller in contour at the first menstruation. Before the next menstrual period the uterus measured 9 cm. and a marked decrease in the general size of the organ was evident both to the touch, and sight, viewed through a speculum. The third menstruation left the uterus 7 cm. in depth, normal in contour, with no evidence of a thickened fundus, no leucorrhœa. Dysuria and constipation had both disappeared.

The patient, who had previously been anæmic in appearance, was now quite full-blooded and in the best of health. The weight had not been noted at the beginning of the treatment, so the exact gain could not be determined, it was estimated, however, at about fifteen pounds.

This is one of the few actual cures reported by this method of treatment, and I have no doubt but that it will remain permanent.

The patient was one who never complained of the strength of the current and never expressed any discomfort from its use. It always acted as a tonic, and she was capable of greater exertion and more work on the days of treatment than on off days.

*Case 3.*—*Large, painful, interstitial, bleeding myofibroma of the uterus. Treatment, seventy applications of galvanism. Result, relief of pain and menorrhagia, diminution in size of tumor, restoration to health.*

Miss L., æt. 39, unmarried, consulted me in November, 1886. *Subjective symptoms:* Excessive weakness, inability to walk without great fatigue, excessive and exhausting

menstruation, lasting from ten to twelve days, sudden attacks of excruciating neuralgic pain in the tumor.

*Objective symptoms:* A large growth, extending from the umbilicus above and filling the pelvis, occupied the abdominal cavity. The mass was smooth and regular, with the exception of a lobe  $2\frac{1}{2}$  inches in diameter, which appeared to be attached to the left side of the main growth. Measurements of abdomen, at umbilicus  $30\frac{1}{2}$  inches; midway between umbilicus and pubes, 35 inches. Cervix large and patulous, canal small and tortuous—the flexible probe, upon withdrawal, presented the appearance of a right-handed corkscrew. Depth of uterus 21 cm., or about  $8\frac{1}{2}$  inches.

The treatment advised and adopted was a strong current of galvanism applied by Apostoli's method. A probe of pure platinum was constructed which would easily conform to the shape of the canal. I found great difficulty, however, in inserting this electrode, because of the peculiar contortions of the canal. Perseverance and care, however, overcame all obstacles, and after a few treatments there was no further trouble. After the internal electrode was in position it was attached to the positive pole, a large abdominal animal membrane electrode was applied externally and attached to the negative pole. A current was gradually turned on until, at the first treatment, 100 ma. was attained. The treatment carried on in this way never produced any discomfort further than a slight burning sensation of the skin beneath the external electrode, although currents of 500 ma. were sometimes employed.

November, 1886. Patient received nineteen intra-uterine galvano-positive treatments. Has had no attack of neuralgia since commencement of the treatment. Menstruation lasted six days.

December, 1886. Thirteen galvano-positive treatments had been given when menstruation appeared, one week earlier than usual, and lasted eight days; flow profuse, no pain.

January, 1887. Sixteen intra-uterine treatments—eight galvano-negative and eight galvano-positive. Menstruation again appeared after the regular interval, and lasted but two days. This was followed in January by eight galvano-negative treatments. Patient at this time was much improved in general health and in the best of spirits. Since coming to Chicago she had not had a single return of the paroxysms of pain formerly so much dreaded.

February, 1887. Seventeen treatments; ten galvano-negative, seven galvano-positive. Depth of uterus, 10 cm.; tumor visibly reduced. Menstruation lasted five days and was normal—no pain. Patient greatly improved in general health.

March, 1887. Nine treatments, all galvano-negative. Patient returned to her home March 11.

*Condition at this time:* Depth of uterus, 18 cm. Measurements of abdomen at umbilicus, 29 inches; midway between umbilicus and pubes, 33 inches. While there was this decrease in the abdominal measurements, the patient had gained considerably in flesh otherwise. Patient expressed herself pleased with results of treatment, and left with intention of returning upon the reappearance of any of the old symptoms.

During the spring and summer the health of the patient continued to be good but, fearing the tumor was again increasing in size, she returned in October to continue treatment.

Examination October 10: Depth of uterus the same as when patient left, 18 cm.; abdominal measurements, umbilicus 32, and midway between umbilicus 34 inches, showing that the tumor is rising in the abdomen. Has had no menorrhagia and no pain since treatment was discontinued.

October, 1887. Patient received fifteen treatments, all intra-uterine galvano-negative. Menstruation appeared after second treatment and was perfectly normal.

November, 1887. Nineteen treatments. all galvanonegative. Menstruation normal.

December, 1887. Eleven treatments of the galvanonegative variety were given. Patient returned home December 17 improved in every way. Depth of uterus 16 cm. Abdominal measurements, at umbilicus 30 inches; midway between umbilicus and pubes, 33 inches.

Patient writes January 30, 1888, as follows: "I believe if it had been possible for me to continue with you from the time of the first treatment to the present time, I would have been entirely relieved of this tumor. If it becomes necessary for me to come to you again I shall try to arrange so that I can remain until there is no longer any need for treatment. I feel that I would like any one suffering with a similar trouble to know how much relief I have obtained.

1891. I saw the patient in October of this year; she was in perfect health and the tumor was so much decreased in size that no deformity was noticeable.

*Case 4.—Fibro-myoma of posterior wall of fundus. Treatment: 62 applications of galvanism. Result: Growth absorbed, all symptoms relieved—Symptomatic cure.*

Miss H., Fulton St., Chicago, unmarried, age 24, menstruated at 17. Dispensary case.

This patient presented herself at Chicago Policlinic Dispensary, May 17, 1887. Complained of excessive flowing, which exhausted her so as to interfere with her duties as a domestic. Paroxysms of pain occurred frequently without warning through pelvic region, from the bladder to the rectum. These, apparently, bore no relation to menstruation. Patient was anæmic; weight 110 lbs.; complained of difficulty in urination; bowels constipated; symptoms had been increasing in severity for two years; has had no local treatment; has taken some internal medication without result.

Local examination: Vagina small and sensitive. Cer-

vix-uteri small, and situated well back in the hollow of the sacrum. Uterus by bi-manual manipulation appeared about the size of three and one-half months' pregnancy. Impossible to introduce sound at first visit.

At second visit was able to introduce a flexible bougie to the depth of 10 cm., or about four inches, the probe took an anterior direction, this was followed by an Apostoli intra-uterine sound of platinum, which was attached to the negative pole of the battery. The abdominal electrode attached to the positive pole was applied, and a current of 300 ma. gradually turned on without the slightest discomfort to the patient. This was followed by five negative intra-uterine treatments, on successive days, and immediately before the next menstruation by four positive intra-uterine applications. During these ten treatments the current reached on two occasions to an approximate strength of 500 ma. The patient at these times experienced, apparently, no great discomfort. I discovered, however, that the effect on the mucous membrane of the uterus was too severe, and the current was never afterward allowed to pass 300 ma.

The menstrual period following was free from pain, and the paroxysms which previously had been so distressing, did not occur again. The flow was more profuse than before.

During the next intra-menstrual period patient received fifteen treatments—ten negative, followed by five positive. The former with Apostoli's probe, with a 300 ma. current, the latter by my concentration electrode, 3 mm. in diameter and 4 sq. cm. surface requiring 100 ma. current.

Second menstrual period passed without pain. The flow lasted three days, and was less in quantity than at any time for the past two years. Uterus measured, August 27th, 8 cm.

During next intra-menstrual period sixteen treatments were given—all negative—with the flexible electrode, requiring 100 ma. current.

Third menstruation free from pain, lasted four days, perfectly normal.

Twelve negative treatments were given during the next month. The following menstruation lasted three days, the flow being very scant.

The uterus at this time measured but 7 cm., and was but little larger than normal. The patient had become strong and hearty, weighed 122 pounds, and declared herself perfectly well. She was with difficulty persuaded to take a few more treatments—ten in all—when she stopped coming of her own accord. When seen in December she was well in every respect.

*Case 5.*—*Large, painful, hæmorrhagic myo-fibroma of the uterus, filling pelvis and lower abdomen. Thirty applications of galvanism. Symptomatic cure.*

Miss T., unmarried consulted me April 1, 1887. Eight years ago she discovered a tumor for which, in 1881, she consulted Dr. T. Addis Emmett, and remained under his care for several months, the principal treatment being the application of tincture of iodine and glycerine tampons. Since that time she has consulted other physicians, but the symptoms have gradually increased, the principal being difficulty in locomotion, frequent and painful urination, chronic constipation, palpitation of the heart, loss of flesh, general weakness, excessive menstruation, lasting from eight to fourteen days, being very violent the first five days.

*Objective Symptoms.*—Large tumor, about the size of a four or five months' pregnancy, occupying the pelvis, of interstitial variety, increasing the depth of the uterus to 19 cm., or  $7\frac{1}{2}$  inches. Cervix large, patulous, and directed toward the sacrum, and entered with great difficulty with flexible probe. Canal exceedingly tortuous and not easily traversed.

*Treatment: April.*—Eighteen intra-uterine galvanopositive, and eight intra-uterine galvanonegative.

*May.*—Five intra-uterine galvanonegative, making in

all thirty applications, the current varying from 50 to 250 ma. The galvano-positive treatments were administered first, and until menstruation appeared, which was so modified that it was followed entirely by the galvano-negative treatment. While I advised the patient to remain longer with me it was necessary, for private reasons, for her to return home. During her stay in the city, and when under treatment, her general health and nutrition were much improved.

*Results.*—May 6th, uterus reduced in depth 3 cm., measuring at present 16 cm. Tumor visibly reduced, locomotion greatly improved, general gain in flesh and strength.

Not having had an opportunity of examining the patient since that day I have no means of judging of her condition except from her own words: "You write, Dr. Martin, to know how I am. I am decidedly better. I have not been as well in ten years. I am a surprise to my friends and to myself, too."

This patient when last heard from, October, 1891, was in perfect health. While I have never seen her since she left my care she maintains that the tumor has completely disappeared and that she is perfectly well.

*Case 6.*—*Myo-fibroma of the right horn of the uterus. Excessive hæmorrhage, accompanied and followed by excruciating pain. Sixty-two applications of galvanism. Cure.*

Mrs. M., æt. 29, married two and a half years, no children: residence Hyde Park, Ill. Consulted me March 31, 1887. Menstruation preceded, and until thoroughly established, accompanied by pain. Excessive, but not exhaustive flowing has been the rule, lasting on an average seven days. The disappearance of menstruation is followed the succeeding day by the most excruciating pelvic neuralgia that it has been my lot to witness, which lasts about two weeks, and while continuous has periods of greater and lesser degrees of violence.

Local examination revealed the cervix uteri normal and in proper location. A flexible probe entering uterus passes to the depth of 8 cm. or a trifle over three inches, and is posteriorly deflected striking a very tender point at its distal extremity, which causes pain similar to that experienced after menstruation. Bi-manual manipulation reveals enlargement of the right horn of the uterus, with a solid growth the size of a goose egg protruding from the surface in the direction of the right ovary. By rectal abdominal examination this proves to be growing from the fundus of the uterus. The whole gives the impression of a right lateral retroversion of a uterus fully four inches in length.

This patient had received treatment and advice from some of the best physicians in the country, including one of the leading gynaecologists of Chicago, but had never found the slightest relief. It was with the idea of receiving the galvanic treatment that she was sent to me.

Considering the case suitable for the Apostoli treatment, I commenced it in April. I introduced an intra-uterine flexible electrode 3 mm. in diameter, with an active surface of 2 sq. cm. in such a manner as to bring the active portion of the electrode in accurate contact with the sensitive portion of the uterus, which had been discovered in probing. It was then attached to the negative pole of the battery, the circuit completed by the abdominal electrode, and a current of 50 ma. carefully turned on. At the end of about three minutes the patient complained of the "old pain." The current was immediately reduced and the treatment ended. She was given stimulants and directed to remain quiet. The pain gradually subsided, and at the end of an hour she was able to return home.

The next treatment, April 4, was similar to the first, save that a much weaker current was used in order to avoid the previous unpleasant effects, and to regain the confidence of the patient. In April, twelve treatments were administered, the strength of the current being gradually increased,

until the 50 ma. required were easily tolerated. The first menstruation appeared in the last week of the month and lasted five days. It was followed by the customary pain which, however, was reduced in duration from two weeks to two days.

In May, eight treatments were given; four galvanonegative and four galvanopositive. This month the menstruation lasted but four days, and was succeeded by one day of pain, which was less severe than formerly.

In June, twenty-four treatments were given, all galvanonegative. Menstruation this month lasted four days, the flow very greatly reduced, and to the delight of the patient, the old pain failed to reappear at all.

In July, nine treatments were given, all galvanonegative. Menstruation was perfectly normal. The depth of the uterus reduced to 6 cm. and the foreign growth had almost disappeared.

In August, eleven treatments, all galvanonegative, were given. Menstruation normal and patient's general health excellent.

In September, seven galvanonegative treatments. Tumor still reducing.

October, the patient received one treatment on the 3d of the month. She then left the city for some time and I did not see her again until December 8, when I found by examination that her pelvic organs were perfectly normal. The uterus measured 6 cm. in depth. The growth was imperceptible. The two menstruations passed while absent were perfectly normal. The patient was discharged cured. I see her frequently, and she remains in the most perfect health.

*Case 7.*—*Large subperitoneal fibroid growth, about 8 inches in its long and 4 in its shorter diameter, with irregular contour, attached to the entire fundus and posterior wall of a slightly enlarged uterus. Thirty applications of galvanism. Symptomatic cure.*

Mrs. H., married, age 45. no children, no miscarriages, was referred to me by Dr. A. Reeves Jackson, August 22, 1887. She first menstruated at 17, and was normal in this respect until about 12 years ago, when a slight increase in quantity of flow was noticed, which has gradually increased up to the present time. Now menstruation lasts from five to six days, is profuse, and is accompanied with considerable pain. Serious pressure on rectum and bladder is complained of, which is the source of greatest discomfort to patient and is the cause of her seeking relief.

*Objective Symptoms:* A solid fibroid tumor, 8 by 4 inches in diameter, occupying and dilating the upper portion of the vagina, completely fills the pelvis. Protruding from its lower portion and almost reaching the vulva is the cervix, from which can be traced above, the body of the uterus. Its canal, which is posteriorly directed, being 8 cm. or a trifle over 3 inches in depth. From the neck of the uterus the tumor extends as an irregular mass in all directions, pressing upon the rectum posteriorly and the bladder anteriorly, and is almost immovable.

*Treatment.*—August 4th, intra-uterine galvano-positive treatment, by means of the flexible intra-uterine electrode, requiring 100 ma. current, were given. In the early part of September two more galvano-positive treatments were given. The effect of these six treatments so modified the following menstruation that in the succeeding applications the galvano-negative current was employed entirely. During the remainder of this month and until the 15th of November 19 intra-uterine galvano-negative treatments were given, when the condition of the patient was as follows: Menstruation for the first three months normal, general health remarkably improved. Pressure on rectum and bladder almost entirely relieved. Tumor reduced in size approximately one-third, and has become quite freely movable. The uterus is less than 7 cm. in depth. From this time until December 15th, I varied the treatment and

gave 10 intra-vaginal galvano-negative applications. The vaginal electrode being so placed as to cause the current to pass through the mass of the tumor situated behind the uterus. This was done in order to reach that part of the tumor which was inaccessible owing to the shallowness of the uterine canal by any other means save galvano-puncture, which operation I always seek to avoid if possible. The patient was at this time so much improved, that by my advice she discontinued treatment, with the expectation of returning if any unfavorable symptoms should reappear. I have not heard from this patient since she left my care three years ago.

*Case 8.*—*Large hæmorrhagic, interstitial, subserous, fibroid growth of the uterus. Twenty-one applications of galvanism. General health improved; pain and pressure on bowels relieved; tumor reduced one-third. Still under treatment.*

Mrs. B., age 39, married, three children, youngest child 7 years old, one miscarriage. Was referred to me by Dr. H. T. Byford, September 21, 1877. The tumor had been discovered by her family physician about two weeks previous to date.

*Subjective Symptoms.*—Difficulty in locomotion; bowels obstinately constipated; constant and increasing disurea; menstruation profuse and exhaustive; profuse leucorrhœa; constant backache and general feeling of bearing down.

*Objective Symptoms.*—Large unyielding growth, filling pelvis and lower part of abdomen, attached to the whole fundus and posterior wall of the uterus in such a manner as to greatly enlarge that organ. Depth of uterus 16 cm., or about 6 inches; cervix large and patulous; canal long, easily admitting a sound 5 mm. in diameter to its full depth, which takes first a posterior direction, afterward curves anteriorly, and when withdrawn presents the appearance of one-third the arc of a circle. The uterus and tumor are movable, the latter fills the pelvis, and rises

above it so as to considerably enlarge the lower abdomen. Measurement of umbilicus 39 inches, midway between umbilicus and pubes at most prominent portion of growth. 44 inches.

*Treatment.*—From September 21st to December 20th, 21 intra-uterine treatments were given. The internal electrode employed was of the flexible variety, 5 mm. in diameter, and had an active surface of 4 sq. cm., requiring a current of 100 ma. It was used as a positive electrode, in all, six times; as the negative, fifteen.

*Results.*—The general health of the patient commenced to improve immediately; first menstruation was sufficiently modified to greatly encourage her; pain and pressure in bowels soon greatly relieved.

*Condition on December 21, when temporarily discharged.*—Tumor reduced fully one-third; general health much improved; notwithstanding a considerable gain in flesh, the abdominal measurements are, at umbilicus, 38 inches, as against 39, three months ago, midway 40, as against 44. Depth of uterus reduced from 15. cm to 12 cm. Menstruation normal; pressure on bladder and rectum greatly relieved; all pelvic discomforts gone; walks with ease.

The patient at this time was so much improved that I advised her to stop treatment for a time and await results, and to return should it prove necessary.

November, 1891. At this time the patient was in a condition of symptomatic health.

*Case 9.*—*Myo-fibroma of the anterior portion of the neck and body of the uterus, 7 cm. or a little less than 3 inches in diameter. Sixty-one applications of intra-uterine negative galvanism. Cure.*

Mrs. T., aged 27. married five years, no children, no miscarriage.

*Subjective Symptoms.*—Frequent and difficult urination; profuse, but not exhaustive, menstruation, with much pain during the latter portion.

*Objective Symptoms.*—Depth of uterus 8 cm., or  $3\frac{1}{4}$  inches; sound passes in the direction parallel to the axis of the body. On the anterior wall of the body and neck of the uterus is a hard mass, or tumor, which would measure approximately, 7 or 8 cm. in diameter, of a smooth, regular exterior and quite freely movable with the uterus. Trouble has been developing for about four years.

The diagnosis in this case was first made by Dr. A. E. Small, who had during my absence taken charge of my clinic at the S. S. Dispensary, where the patient presented herself.

The first treatment was given June 7th. An Apostoli intra-uterine platinum probe was inserted to the bottom of the uterine canal and connected with the negative pole of the battery. The large abdominal electrode was employed to complete the circuit by applying it over the tumor on the abdominal surface in such a position as to insure the passage of the current through the mass of the growth. A current was then gradually turned on until 200 ma. was reached. This was allowed to pass for about five minutes, the patient experiencing no discomfort. Considerable discharge of a watery character took place from the uterus and a bubbling of gas was noticed around the staff of the electrode as it made its escape through the fluid. Eleven of these treatments were given during June, a current being tolerated a number of times of as high intensity as 500 ma. The tumor showed a tendency from the beginning to reduce rapidly in size. The menstruation this month was rather more profuse than usual, but painless.

July 15, intra-uterine negative treatments were given. Highest intensity employed, 300 ma. No discomfort, except tenderness of the skin; growth rapidly decreasing; uterus 7 cm.; menstruation normal.

August, fourteen intra-uterine negative treatments given. Highest intensity 250 ma. Patient declares herself well; growth appears simply as a thickening of the

anterior wall of the uterus, or as an anteversion; pressure on bladder gone; menstruation rather profuse.

September. It was with difficulty that I could convince the patient that it was still necessary for her to receive treatment. A few were given this month by Dr. Wimermark. Highest intensity 200 ma.

October. Patient with difficulty induced to take ten more treatments.

Discharged October 24th. Depth of uterus 6 cm., or about  $2\frac{3}{4}$  inches; thickening of the anterior wall no longer perceptible; all other unnatural symptoms have disappeared. Result: cure.

*Case 10.*—*Myo-fibroma of fundus and posterior portion of uterus, accompanied with menorrhagia. Twenty-three intra-uterine applications of galvanism. Cure.*

Mrs. M., æt. 32, three children, youngest 3 years of age, consulted me at the South Side Dispensary some time in the early part of October, 1887.

*Subjective symptoms:* General weakness and increasing difficulty in locomotion. Menstruation profuse and exhausting in amount, and accompanied with severe contractive pain; duration about eight days. Constipation has been of late a distressing symptom. General pelvic pressure and painful bladder symptoms are complained of, which have become more and more aggravated for about two years. Appetite and digestion fair.

*Objective symptoms:* Cervix uteri large and patulous. Canal large and easily followed with flexible sound to the depth of 11 cm., or  $4\frac{1}{3}$  inches. Course of sound for about 2 inches parallel with axis of pelvis, then takes a sudden bend anteriorly to the bottom of the uterus. In a bi-manual manipulation the uterus presents the appearance of a  $3\frac{1}{2}$  months' pregnancy, smooth and movable. The greatest thickness of the walls is in the fundus and posterior portion of the uterus below the fundus, although the whole organ is

considerably hypertrophied. The uterus proper is quite decidedly anteverted, as shown by the probe.

This patient, commencing treatment in the middle of October, received twenty-three applications up to the middle of December. The internal electrode employed was of the flexible variety, 3 mm. in diameter, with an active surface requiring a 100 ma. current. The first six treatments given were of the intra-uterine positive, the remaining seventeen were intra-uterine negative. The current was well tolerated and the patient, judging from her faithful attendance, was not displeased with the effect. Menstruation was markedly modified for the better at its first appearance after treatment was begun. The general nutrition of the patient commenced to improve at once, and after the first month locomotion was accomplished with much greater ease, and the pelvic symptoms were greatly relieved, including the constipation. In this case a peculiarity noticed was a much larger flow of clear watery fluid from the uterus during a negative intra-uterine application than is usual. At first this flow was very profuse, sometimes filling the speculum during a treatment. It gradually became less and less, however, as the treatment progressed, until finally it was no more than in ordinary cases.

The recovery of this patient was uninterrupted, and when she received her last treatment, December 24, she was in the following condition: Uterus reduced fully one-half in size—its depth being reduced from 11 to 8 cm. The abnormal thickening of the fundus and sides of the organ had entirely disappeared. The large and patulous cervix was reduced to normal, and the discharge from the cervical canal ceased. The uterus was movable. Menstruation painless and normal in quantity, lasting but three days. Constipation had disappeared and the pressure on bladder was entirely relieved. Patient was in better health than at any time since birth of first child.

*Case 11.—Large, interstitial fibroid in posterior wall*

*of uterus. Hæmorrhage. Negative galvano-puncture. Symptomatic cure.*

Miss C., colored, unmarried, age 28, was referred to me from Helena, Mont. She was in a pitiable condition, scarcely able to walk, thin, bloodless and in great pain. Upon examination a fibroid tumor filling the whole abdomen below the umbilicus was discovered. The cervix was drawn up behind the symphysis, out of reach of the finger. It was impossible to introduce a probe or bougie of any kind into its canal. Presenting, smoothing out the posterior vaginal wall, was a solid mass of fibroid projecting from the posterior wall of a greatly enlarged uterus. This latter pressed upon the lower bowel causing almost effectual obstruction. The bladder symptoms were severe and painful. Bleeding was constant. Patient weighed 96 pounds.

Intra-uterine treatment was out of the question as the most flexible bougie could not by any maneuver be insinuated into the canal. The most reckless operator would not have thought of operating on such a case. Nothing then seemed left but galvano-puncture.

The treatments were begun at the Polyclinic Hospital. The negative galvano-puncture was employed. The patient was carefully prepared with a bichloride vaginal douche, and kept constantly clean between treatments by the frequent employment of the same. A platinum electrode was used with a point which could be thrust into the tissues for 2 cm. The point of puncture selected was through the posterior vaginal wall (where it was spread firmly over the protruding fibroid mass) into the solid presenting fibroid. No anesthetic was required and the dose varied from 150 to 300 ma. for a period of five minutes. The application was given twice a week at the beginning, while the patient was in bed, and later once in seven days.

The electricity had a marvelously beneficial effect. The patient improved from the first treatment. In three weeks she was free from pain, the flowing had reduced one-

half. The tumor had perceptibly diminished in size, she was able to be up and was gaining in strength and flesh. At the end of four weeks she astonished us all by informing us that she had answered an advertisement for a cook in a large boarding house and had accepted the position. This work she was able to do at the same time faithfully continuing the electricity, until at the end of three months she decided to return home. At this time she claimed perfect health. Her tumor had reduced fully one-half, menstruation was normal, all pressure symptoms had disappeared and she weighed 120 pounds. She promised faithfully to communicate with me in the future regarding her health, but I have not heard from her.

The record of this case being very incomplete, and such records as were kept not now being at my disposal, I am unable to state the exact number of treatments given or their exact dates. The case was well known, however, at the time, and was of considerable interest to a number of medical gentlemen who watched the treatment. No untoward symptoms were experienced at any time. Later in her career with me she would return after resting but an hour and assume her duties as cook (a course, of which I very much disapproved) apparently without detriment to her.

*Case 12.—Large interstitial, hæmorrhagic fibroid. Six inches in depth. Intra-uterine galvano-puncture treatment. Cure.*

Mrs. X., age 30, mother of several children, was referred to me by Prof. D. T. Nelson, about two years ago for galvanic treatment for a bleeding fibroid. Patient very anæmic, weak and thin from repeated exhaustive floodings. Constant pain in pelvis, pressure on bladder and rectum; locomotion accomplished with difficulty on account of pelvic pain and pressure. From physical examination, uterus found much enlarged and extending nearly to umbilicus. Uterine sound entered canal to the depth of six inches, and

deflected to the left. Some hæmorrhage followed the introduction of the probe. Treatment was commenced at the Woman's Hospital, and later as the patient improved was continued at my office.

At the beginning of the treatment an Apostoli electrode was employed and continued for two weeks three times each week. The electrode was inserted to the bottom of the canal, and as strong a current as the patient could bear was administered (the canal being so deep and the exposure of the electrode so large there was no danger of undue cauterization), reaching at times as high as 150 ma. At the end of the two weeks treatment was suspended. Finally, with some pain the flow appeared with great suddenness and with all the violence of former times. The patient was referred back to Dr. Nelson. All the ordinary remedies, including ergot and hydrastine, were employed without the slightest avail. The flooding continued four, five, six, seven and eight days without any tendency to cease. The patient was almost completely exsanguinated. Tamponing of the vagina was systematically resorted to. There was no uterine pain, after the outset; no uterine contraction to speak of. The hips and lower extremities were elevated to assist in controlling the waste. At last, after twelve or fifteen days, slight signs of cessation appeared. She was gradually nursed back to life and at the end of six weeks was able to go about in a wheel chair.

Consultation discovered that a marked decrease in the size of the tumor had occurred. I also learned that during my treatment of the case with electricity and until after the hæmorrhage had been continuing for some time, large doses of ergot and hydrastine had been administered to the patient. This I believe was a mistake. I have seen the same course pursued in other cases with the same bad results. It will be remembered that the menstruation was temporarily postponed. This was no doubt caused by a partial sealing of the vessels of the mucous membrane of the

uterus as an effect of the use of the positive pole—forming as it did a temporary dam. Ergot in large doses was being systematically administered, which had a tendency to produce powerful uterine contraction. These contractions in time caused an expulsion in mass of this dam of coagulated tissue which had prevented hæmorrhage. This succeeded at once, of course, in uncovering the bleeding vessels more than ever before, and a hæmorrhage naturally followed, which well nigh ended our patient. The ergot caused the difficulty. I make it a rule never to give large doses of ergot at all when employing electricity for hæmorrhage and none at or near the menstrual period.

From this time on our patient rapidly improved under the same form of treatment that was at first given, minus the ergot and hydrastine. The uterus rapidly decreased in size, the hæmorrhage ceased, the menstruation became less than normal, the patient began to walk, and at the end of three months time considered herself a well woman. This was about six months after the first treatment. The uterus was but little more than the normal proportion. The patient at present time is perfectly well.

*Case 13.—Large, interstitial, bleeding fibroid, extending to umbilicus, with an uterine canal 11 inches in depth. Concentration intra-uterine treatment. Symptomatic cure with almost entire reduction of tumor.*

This case was referred to me from the outdoor clinic of St. Luke's hospital, by Dr. Frank Cary. Mrs. Z., age 40, mother of one or more children, presented herself at the clinic of the Post-Graduate Medical School about one year ago. She had been suffering with exhaustive hæmorrhage, which of late had become almost continuous. For about three years ergot, astringents, and all other forms of conservative treatment had been carefully instituted, including curetting, without the slightest improvement being manifest. Upon examination I found a uterine tumor extending to the umbilicus and a canal nearly eleven inches in

depth. The uterine walls seemed equally hypertrophied in every direction. The slightest probing was followed by profuse hæmorrhages. The patient was in a state of extreme weakness, pale, nearly bloodless, and unable to make more than the feeblest efforts to assist herself.

What was to be done with her? We had an uterine canal nearly eleven inches in depth and a patient who from extreme weakness would not tolerate more than 100 ma. The canal would admit a flexible bougie about 5 mm. in diameter, and it was necessary to attack every portion of that uterus with the positive pole, using a minimum current density of 25 ma. for each sq. cm. of surface. Clearly, if it was to be done at all, it would be necessary to attack it by piecemeal, as an electrode, which would completely fill the canal at all points of its enormous surface, would require a current of nearly 1100 ma. in order to obtain sufficient density to check hæmorrhage.

Therefore we chose an electrode of 4 sq. cm. active surface and 5 mm. in diameter and commenced attacking the bleeding surface in small portions. At the first treatment this electrode, with its distal end exposed, was inserted to the bottom of the canal and the desired 100 ma. current allowed to act for five minutes. After the current was turned off the electrode was withdrawn just the distance of the length of the active surface of the electrode and the current turned on for five minutes longer. In this manner about two inches of the distal end of the uterine canal was thoroughly seared over with a coagulum and the patient had not experienced any inconvenience. At the next treatment two inches more of the canal was attacked, and at the end of about five treatments the whole canal was pretty thoroughly covered. As soon as the canal was partially treated the hæmorrhage commenced to decrease and the intermenstrual flow had entirely ceased when it was completed. Of course the same process was repeated several times as rapidly as possible, the patient taking treatments as often as every

other day a portion of the time. After two months' treatment the inter-menstrual hæmorrhage was entirely checked and the menstruation was materially lessened. After hæmorrhage had been controlled the patient was treated during the early parts of the month with the ordinary Apostoli electrode, and frequently tolerated as high as 300 ma.

This patient not only improved as regards hæmorrhage, but she improved in every way from the start. The tumor began to reduce, the general health was better, locomotion became less difficult, pain subsided, pressure symptoms disappeared, and in every way the patient manifested signs of getting well.

At present she is well. No hæmorrhage, menstruation very slight, no symptoms of any kind, and the woman is working very hard at manual labor earning her own living. The tumor is a mere relic of the past. Uterine canal measures  $3\frac{1}{2}$  inches and a slight enlargement of the uterus can be discerned by bi-manual manipulation.

## CHAPTER XIX.

### FIBROID TUMORS.

#### FAILURES—CAUSES OF—WITH CASES.

\*Like all great discoveries, the Apostoli method of treating fibroids led its followers in their first enthusiasm of admiration to expect far more from it than its author really claimed for it himself. Hence in many instances disappointment followed.

Practically, Apostoli's method has proved a great discovery. Theoretically it seemed to be a greater discovery than it practically has proven. Hence, condemnation from the merely theoretical.

From the reaction following the disappointment of those who always mistake new things as the dawn of the millennium, the Apostoli discovery has made healthy progress. It came, there was a large place for it, and it has come to stay.

We have discovered by developing it that it will not cure all cases of fibroid tumors of the uterus; that there is still room for the scalpel. About 75 per cent. of all fibroid tumors of the uterus however, because of electricity, should never be touched with a knife.

I wish to present the history of a few of my early cases in which failure was recorded, and allow them to point in a small way their lessons. They demonstrate forcibly that electricity should be employed with the same

\*The substance of this chapter was the subject of a paper presented to the American Gynecological Society, 1891.

common sense as should be employed with any other powerful therapeutic or surgical agent.

The first case is that of a large supposed fibroid tumor, which was referred to me for electricity by the late Prof. Byford. It represents a rare fact, and one in which a positive diagnosis is seldom made without an exploratory incision. The action of electricity upon them, because of a certain peculiarity, possesses a diagnostic value.

*Case 1.—Fibroid tumor of the uterus of large size, of many years standing, treated by electricity, both intra-uterine and negative puncture, without permanent improvement, and finally abdominal hysterectomy discloses a fibro-cystic tumor.*

Miss S., age 36, unmarried, noticed tumor three years before consulting me, but had been conscious of increased size of abdomen for several years before that time. Menstruation was regular, not excessive but somewhat protracted, at times lasting ten days. Severe dysmenorrhœa of a spasmodic nature was complained of. Complained of constant pain in left side in region of descending colon and sigmoid flexure. Patient about 5 feet 7 inches in height, weight 110 pounds. Tumor produced considerable deformity from its size, extending as it did to two inches above umbilicus. The patient stated that the tumor was growing rapidly. The uterine canal was entered with difficulty by an Apostoli intra-uterine platinum electrode to the depth of 5 inches.

This patient was put upon systematic intra-uterine galvanism according to Apostoli's principles. The first peculiarity noticed in the treatment was the fact that she could not tolerate any considerable dose. A current of more than 50 to 60 milliamperes would invariably be followed with a very unpleasant reaction, in the way of severe pain and nervous excitement. However, as long as the current was not allowed to exceed 50 ma., the patient experienced the ordinary general tonic effect of the galvanism. I was soon convinced that the small doses tolerated

would accomplish results slowly, and advised the negative galvano puncture (Apostoli-method). This was attempted twice but with such exceedingly unpleasant results in the way of severe shock and extreme prostration, that I determined to abandon the use of electricity. My results in this case were so much at variance with ordinary cases of apparently the same type, that I was at a great loss to account for them. I advised at this point that the patient return to Dr. Byford for an operation. The patient left me much dissatisfied with the results of my efforts.

Fortunately she did return to my colleague, Prof. Byford, and I had the extreme satisfaction of examining the tumor after it had been removed by the latter surgeon, assisted by Dr. H. T. Byford.

It was of a fibro-cystic nature. About one half of its contents being removable through a large trochar, as semi-solid fluid of an albuminous character. At the operation it was looked upon as a semi-malignant tumor. Subsequent examination together with the subsequent history led to different conclusions.

The above case is only one more proving that electricity is not suitable for the treatment of fibroid tumors which in any way partake of a cystic nature. The patient here was extremely sensitive to electricity. There is only one other condition, except acute inflammation, in which extreme sensitiveness to strong doses in fibroids is noticed, and that is, certain forms of hysteria. Hence, the diagnostic value of the symptom.

The next variety I have to speak of is represented by two cases, in which the uterine canal was so distorted that the intra-uterine treatment was impossible, and galvano puncture was not accompanied by satisfactory results.

*Case 2.*—Mrs. X., 43 years of age, was referred to me for treatment by Dr. Christie, of Pittsburgh, Pa., June 1, 1889. The patient had no children, but gave a history of several miscarriages. Menstruation was excessive and very

painful at the time she consulted me. Menstruation had been excessive for 4 years. First noticed an enlargement about four years ago. Bladder symptoms aggravating from pressure, and locomotion was accomplished with difficulty. The tumor was of an intramural variety, large, filling the whole pelvis and extending within two inches of the umbilicus. The cervix was pushed forward and was crowded high up above the symphysis pubes, in such a lo-

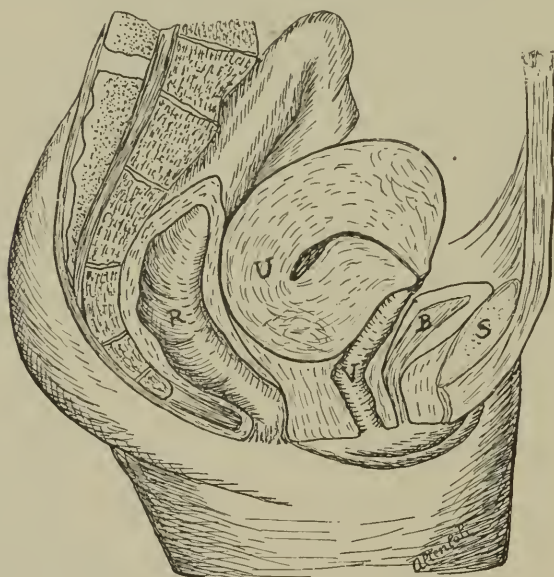


FIG. 67.

cation that it was impossible to enter the canal with any form of electrode or bougie. Fig. 67. The mass of the tumor seemed to occupy a position behind the neck of the uterus and to throw the organ into a position of retroversion.

This patient was given negative galvano punctures extending over a period of three months, the interval between the treatments averaging about seven days. The puncture was advised because of my inability to get an

electrode into the uterine canal because of its distorted condition. The patient bore as high as 250 ma., at various sittings. The symptoms materially decreased in severity, including the hæmorrhage, and the tumor decreased one third in size during the three months. The patient was so much improved that she returned home very well satisfied with the results.

She remained at home for nearly a year in a much im-

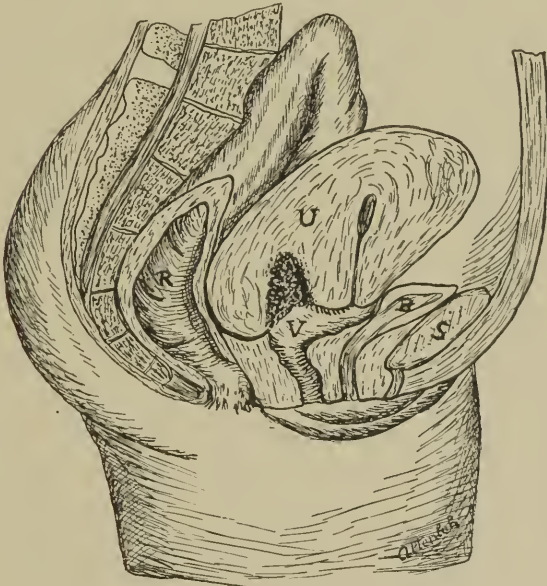


FIG. 68.

proved condition, when she returned because of a rapid increase in size of the tumor.

I again continued the former treatment for two months, stating when I began that I should advise an operation for total removal of the tumor, or the Batty-Tait operation if it were not promptly successful.

Instead of the tumor decreasing in size, it remained practically stationary, notwithstanding vigorous treatment, and the hæmorrhage was again becoming troublesome.

In October, 1890, I removed the appendages. The tumor proving to be upon the exploratory as diagnosed previously, a large intramural fibroid developed in the posterior wall of the uterus. The patient made an uninterrupted recovery, and in the incredibly short period between the time of her operation and her discharge from the hospital, a period of four weeks, the tumor had decreased fully one-half in size.

*Case 3.*—Miss Y. was referred to me by Dr. M. Caldwell, of Waukesha, Wis., for electrical treatment for a fibroid of the uterus of long standing. The growth was a large interstitial tumor enlarging the whole uterus, and producing a deformity simulating a six months' pregnancy. The cervix was crowded well up behind the symphysis and a large symmetrical mass presented in the Douglas cul de sac indicating a retroverted condition of the uterus. The uterine canal could only be entered with the utmost difficulty, because of the extreme distortion, and then only with a flexible bougie or electrode. The introduction of a bougie or electrode to the canal produced considerable pain. The symptoms were pain in tumor, dysuria, sacralgia, hæmorrhage and deformity, accompanied by general exhaustion.

Positive intra-uterine galvanism was instituted and finally rejected because of the extreme difficulty experienced in introducing the electrode and the severe suffering the operation engendered.

Much good was accomplished in relieving the symptoms, however, while the mild currents made necessary by the pain produced by stronger, were not of sufficient strength to reduce the tumor perceptibly.

Finally I resorted to negative galvano-punctures. These were applied about every ten days for nearly three months, the current never exceeding 200 milliamperes. The symptoms were improved and the tumor perceptibly reduced during this time. The treatment was discontinued, and the patient did nicely for several months, when she came to me

and stated that a week before she had had a chill which had been followed by some fever and some colored discharge from the vagina. An examination disclosed a slight excavation just posterior to the cervix, which resembled a bed to a small abscess.

This, apparently, was soon healed. Two months later I was summoned to the patient after she had had a profound chill. Several days followed with high temperature which at one time reached 106.5 degrees. A few days later I succeeded in locating the pus, and evacuating it. The abscess had developed in the posterior wall of the tumor, and had found an opening through the posterior vaginal wall in the location of the previous vaginal galvano-puncture.

Every effort was made on repeated occasions, with the patient anesthetized twice, to effectually get to the bottom of this abscess and to establish efficient drainage. It proceeded to honeycomb, however, and in spite of the best efforts of the best surgical talent in Chicago, nothing succeeded in checking the process of suppuration.

Consultation with Dr. Bayard Holmes and H. T. Byford finally decided upon hysterectomy as the only feasible method of removing effectually the abscess.

I therefore, performed the operation in August, 1891, the patient surviving but 24 hours.

A large abscess cavity was found in the posterior walls of the tumor with several ramifications, one of which had emptied into the uterine canal, another through the posterior wall of the tumor lower down where it was lying in contact with the vaginal wall, and thence through the wall into the vagina, as before described.

It was impossible for me to satisfy myself in regard to the source of infection in this case. I am aware that I have good friends in the profession who would have less difficulty than I in settling this point to *their* satisfaction after reading this report. I will say to *such friends*, my reasons for hesitating to accept their version is the fact, (1) that my gal-

vano punctures on the patient were accomplished at the patient's residence with perfectly aseptic instruments, after the parts had been scrupulously prepared with a bi-chloride douche, the vagina being loosely packed with antiseptic gauze following the operation and perfect rest in bed for twenty-four hours, with a continuation twice daily of antiseptic douches until the next operation. (2) That I have performed the operation hundreds of times before without a single like result. (3) That with an experience of 250 cases of fibroid tumors, I had never seen a suppurating one before, proving to my mind that electricity is itself a preventive of suppuration. (4) Experiments of Apostoli demonstrated positively that electricity is a powerful germicide.

The above two cases are only so many out of a score that I have treated by means of the puncture. They represent my only failures with that treatment, and the last case is the only one in which in all my experience with galvanism I have known pus to develop. Clearly, then, the pus was not the result of the galvanism, but rather, if at all, from the result of my connection with the case, as a result of some failure in the precaution to keep everything clean.

The following three cases represent a rare form of tumor, which, when met with, upset the calculations of the electrician. They are of a remarkably hæmorrhagic character. They are not of large size. Their canals are patulous and are easily traversed by the ordinary forms of the intra-uterine electrodes. Upon applying galvanism, the patients tolerate sufficient dose to make us confident of speedy results in checking hæmorrhage, and in accomplishing a cure. With this apparently favorable outlook the results are dismal failures. Two of the following cases are such and the subsequent removal of the tumors enabled us to solve the mystery.

*Case 4.*—In May, 1890, Mrs. Y., age 36, no children, was referred to me for treatment by electricity by Dr. J. L.

Priestman, of Neponset, Ill. The uterus was enlarged to about the size of a three months' pregnant uterus. The canal was patulous, and easily traversed to the depth of three inches with an ordinary bougie the size of a lead pencil. The subjective symptoms were, excessive and prolonged hæmorrhage, marked anæmia, loss of flesh, severe backache, irregular uterine pains, and general loss of strength.

I commenced at once a vigorous application of positive intra-uterine galvanism with full doses. The applications were made at intervals of from 24 to 48 hours. The general tonic effect of the current was the only beneficial effect that I succeeded in obtaining, much to my surprise and chagrin after a two and one-half months' trial. The hæmorrhage instead of decreasing, increased, and all symptoms remained substantially the same as at the beginning of treatment, with the exception of an improved appetite.

I sent the patient home with the advice to the family physician that the uterus be removed. This course was urged by me with more than usual vehemence, because to my failure with electricity I was inclined to attribute malignancy.

Accordingly, in August, 1890, at the Woman's Hospital, assisted by Dr. Priestman and the House Staff, I removed the uterus per vaginum.

The uterus was purely fibroid. There were five distinct nuclei of development representing as many projecting masses on the interior and exterior of the uterine walls, varying in size from the proportions of a hickory nut to that of a hen's egg. Into the canal were two of these fibroid masses projecting, which served to so distort the canal that a proper cauterization of its interior was impossible. The circumference of the cavity of the uterus had been greatly increased likewise by the projecting masses.

The accompanying cut gives an accurate representation of the uterus one-half size.

*Case 5.*—Miss W., aged 28, was referred to me for the galvanic treatment of a bleeding fibroid, by Dr. Van Duzer, of Chicago, in August, 1890. The patient had had several

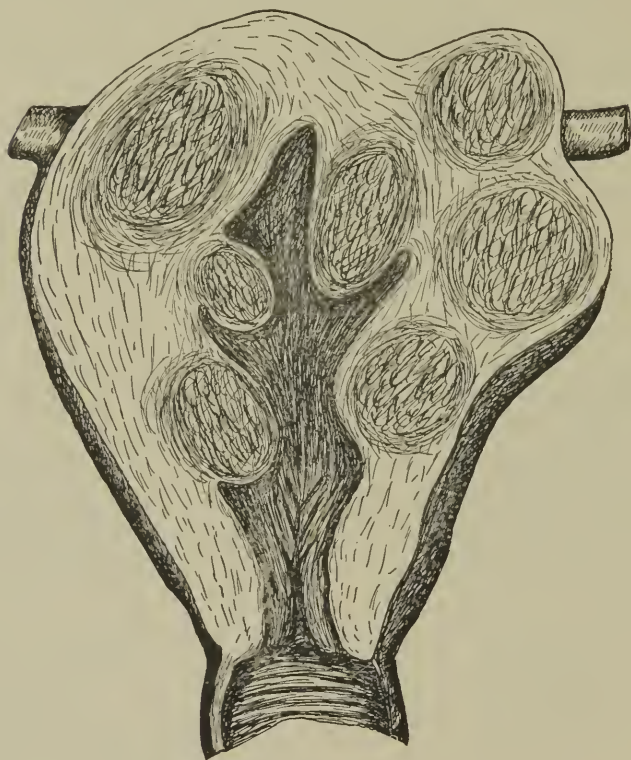


FIG. 69.

operations for curetting by the late Prof. Byford, and had been thoroughly treated with ergot by the latter and her family physician.

I found the uterus about the size of a three months' pregnant uterus. The canal was patulous and easily traversed by a probe.

The principal symptom was exhaustive hæmorrhages at the menstrual periods, which were frequently continuous

throughout the month. As a consequence anæmia and extreme weakness existed.

The case seemed extremely favorable for the Apostoli

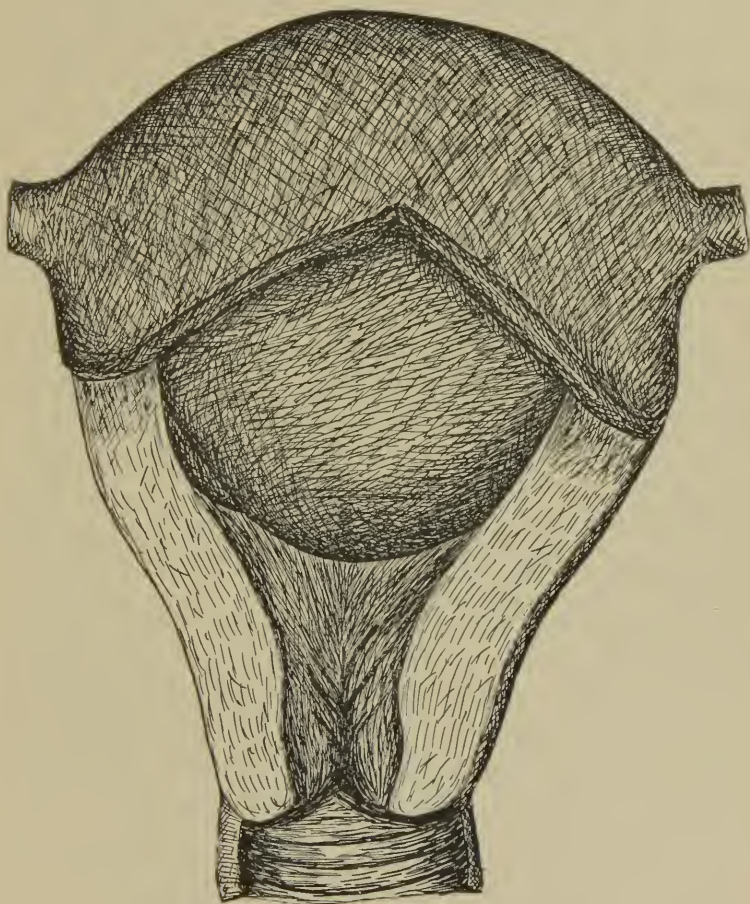


FIG. 70.

intra-uterine treatment. I therefore commenced it with great faith in my ability to establish a cure.

There was no cessation of hæmorrhage at the end of my first month's treatment notwithstanding the ability of the patient to tolerate the full dose required. I still con-

tinued my efforts, however, and at the end of the second month the uterus was perceptibly smaller, and the hæmorrhagic period was slightly shortened in duration. The amount of hæmorrhage in a given time could not be considered less. A third, and even a fourth month's treatment was administered. There were no beneficial results obtained further than a diminution in the size of the tumor, and a lengthening of the interval between the hæmorrhages.

These results were no more satisfactory to the patient than they were to me, and in May, 1891, my friend Dr. H. T. Byford, successfully relieved the patient by a hysterectomy.

The tumor represented a uterus about double the normal size, with a very irregular canal and cavity, because of a large sub-mucous projection from the fundus into its interior. It could readily be understood why my efforts in checking the hæmorrhage had been unsuccessful. The irregularity of the canal and cavity, as accurately depicted in Fig. 70 rendered it impossible to effectually reach the surface of the mucous membrane of the uterus in all its parts.

One point of importance in the last two cases, more important possibly than the distortion of the canal, is these multiple nuclei of developments of the growth. I have learned to become suspicious of these cases where the condition is distinguishable by the irregular external contour of the tumor, and am guarded in consequence in my prognosis. The constant struggle for existence of a number of these points so interfere with each other that acute symptoms are always present to combat effectually all treatment except that by the knife.

Fig. 71 represents one of these cases. It was accidentally discovered by one of my students in a course of operative surgery, in the dead house.

The following conclusions are submitted as summarizing the points suggested by the foregoing cases.

1. Fibro-cystic tumors are not benefitted by electricity.
2. The peculiar sensitiveness of patients with fibro-cystic tumors to electricity makes that fact of diagnostic value in determining that condition.

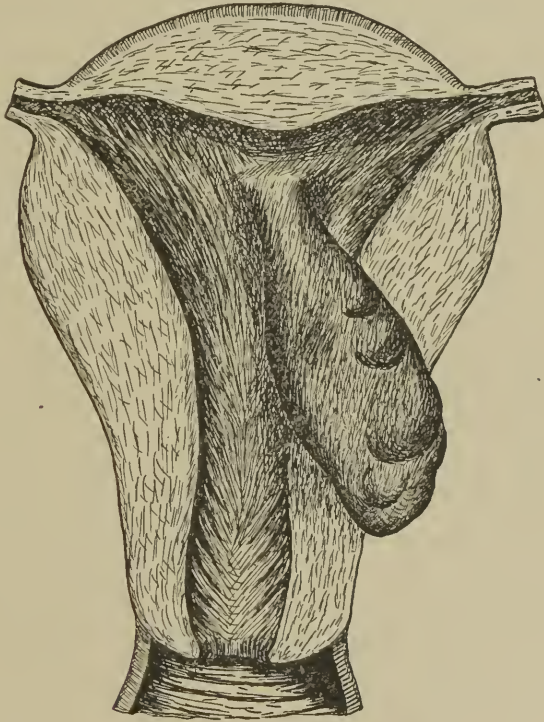


FIG. 71.

3. A fibroid uterus whose canal is so distorted that it is impenetrable to an intra-uterine electrode must submit to galvano puncture or the knife.
4. Galvano puncture should not be resorted to unless the patient can be kept under perfect control, in order to insure absolute cleanliness of procedure and subsequent avoidance of infection.

5. Galvano puncture will sometimes fail to accomplish a cure in very large hæmorrhagic fibroids. '

6. Small bleeding fibroids of irregular external contour indicating multiple neuclei of development are liable to do badly, or at best not to improve under the Apostoli treatment.

7. A bleeding fibroid uterus, with an expanded and irregular cavity, all parts of the interior of which cannot be reached by any form of intra-uterine electrode, will occasionally fail to yield to the Apostoli treatment.

## CHAPTER XX.

### ENDOMETRITIS, CHRONIC METRITIS, SUBINVOLUTION.

**Chronic Endometritis.** I will include under this head chronic hypertrophy of the endometrium, with vascular granulations, for which dilatation and curetting are frequently employed, chronic cervical catarrh in which the deep cervical glands are involved, and in which the characteristic impermeable plug of albuminous discharge is the perplexity of all gynecologists, and lastly, chronic catarrhal inflammation of the entire endometrium.

Chronic endometritis is the result of long continued inflammatory action of the endometrium or of repeated attacks of inflammation continued over a long period. The primary inflammation is caused by nutritive changes from imperfect blood supplies. Long continued passive congestion from displacements, imperfect involution after last confinement, laceration of the cervix or perineum, traumatisms, colds from improper douches, injuries from chemical injections or improper treatment, over indulgence in, or imperfect sexual congress may be mentioned as a few of the indirect causes leading up to chronic endometritis in its different forms.

With the hypertrophic endometrium the uterus is ordinarily slightly enlarged (the difficulty almost invariably being complicated with chronic metritis), the mucous membrane at the os-uteri is everted, red and angry in appearance, the sound is introduced with some difficulty and the pain caused by its insertion into the canal is often acute. Upon withdrawing the probe it is specked with blood and

purulent secretion. The discharge from the uterus is yellow, streaked with blood and occasionally offensive.

This form of endometritis can, in my opinion, be treated with greater satisfaction by means of galvanism than by any other single method. First, of course, everything must be done to seek out the cause and, if possible, eliminate it. If it is a displacement, correct it, and then cure the endometritis, the result of the displacement, by galvanism. The antiseptic, the mild alkaline caustic and the depleting effects of the negative pole are what are sought in the treatment of this form of the disease. As the negative pole is required the electrode may be of block tin or any conducting metal. One about the diameter and shape of an ordinary uterine sound should be selected which will approximately fill the uterine canal. It should be inserted carefully to the bottom of the uterus and the vaginal portion insulated with the rubber muff. The electrode should be attached to the negative pole of the battery, a large abdominal electrode applied and a current of from 50 to 75 ma. gradually turned on. If the patient complains of pain before the latter figure is reached, wait, and if possible, increase it more slowly later to the desired dose. If, however, a strong dose is not borne, be satisfied to approach as near one as is possible without discomfort to your patient. The treatment should last about five minutes. When the electrode is withdrawn, after the treatment, a small pad of antiseptic cotton may be placed against the cervix to absorb the secretion. Stimulating douches of hot water should be given twice daily, and on the days of treatment an antiseptic douche should be ordered as a preliminary to the application. Treatments may be given two or three times a week. The effect of this treatment is often marvelous. The secretions will dry up, the tenderness disappear and the patient take on a condition of tonicity and well being that is surprising.

**Endometritis with Hæmorrhagic Vegetations and**

**Other Granulations.** This condition, the direct cause of which is not always understood, is a complication, if not a form of chronic endometritis. It is characterized occasionally by pain and frequently by hæmorrhage. The passage of an uterine sound is accompanied with great pain and is almost invariably followed by a discharge of blood. It is the condition for which the old classic treatment of dilatation and curetting has been a favorite operation. The indications for treatment are: Removal of the vegetations and granulations and a change of nutrition which will favor reproduction of healthy mucous membrane. These indications are met in a very complete and comparatively painless manner by negative intra-uterine applications of galvanism. The cautery effect of the negative pole is utilized in destroying the granulations and vegetations and the antiseptic and tonic effect of the pole aids in accomplishing healthy reproduction.

We should seek to get the full cautery effect of the negative pole in the treatment of these cases. Therefore, a well fitting concentration electrode should be employed with an exposure so small that the patient can tolerate the current without an anæsthetic and the mucous membrane of the whole canal can be covered by piecemeals if necessary. Therefore, at the first treatment, select an electrode with an exposure of 4 sq. c. m., which will accurately fit the canal. Insert it to the bottom of the canal and after adjusting the external abdominal electrode, gradually turn on a current of 100 milliamperes. This, after acting for five minutes, will thoroughly, as a rule, cauterize the distal end of the canal. If the patient has borne the treatment well, the electrode may be withdrawn sufficiently to cause the active portion to come in contact with the untreated portion of the uterine canal and then at the same sitting, this portion in its turn, may be treated by again turning on the current for five minutes. Thus, the whole mucous membrane of the uterus may be cauterized and its granulations

destroyed at one sitting. If the patient is found on trial not able to take a current strength of 100 milliamperes, an electrode of 2 sq. c. m. should be selected which requires but 50 ma.

After the first cauterization, the case can be treated by the ordinary block tin electrode with complete exposure, the same rules maintaining as in the treatment for simple chronic endometritis. If it is found that one thorough cauterization has not succeeded in removing the new growth, a second or even a third application may be resorted to.

Occasionally hæmorrhage persists after the vegetation has been removed, from the exposed vessels on the cauterized mucous membrane. This can be checked by a few applications of the positive pole. For this, as for checking hæmorrhages everywhere, a current equal to 25 ma. for each sq. c. m. should be insisted upon.

**Chronic Catarrhal Endometritis** is the result of a faulty nutrition of the endometrium from blood famine in the patient in whom it is found. It is characterized by a pale condition of the mucous membrane of the cervix, flabbiness of the vagina and uterus and an abundance of a milky, thin discharge from the lax uterine mucous membrane.

This local condition can be greatly benefited by the proper use of galvanism, if, at the same time, we bear in mind that our remedy, electricity, should have material aid from the proper administration of iron, fresh air, good food, and healthful exercise of the patient receiving it. We must not forget that we are doctors of the whole body, while we are gynecologists, even though we do use electricity.

In this condition the stimulating effect of the negative pole of the galvanic current in mild doses should be relied upon. An electrode should be introduced into the uterine canal which will fill it. It should be the negative pole and a current of from 30 to 40 ma. should be switched on. It should be retained at this point five to eight minutes. The

treatments should be given as often as two or three times a week.

#### CHRONIC ENDOCERVICETUS.

By this, I refer to that condition in which the deep cervical glands are involved with an abundant discharge of an albuminous character. Every gynecologist has been perplexed by this almost intractable difficulty. In galvanism we have a means of getting to the bottom of these glands and of exposing their walls so that proper medication may be employed. In the conditions of the endometrium heretofore referred to in this chapter, we have utilized the characteristic local effects of the negative pole because we sought an alkaline caustic action, while here, we seek for the characteristic local effect of the positive pole in order to get coagulation. Accordingly, we should introduce into the cervix a metal electrode which will fill the canal and attach it to the positive pole of the battery, the circuit being completed in the ordinary way by means of the abdominal electrode. The current should be turned on gradually, as strong as the patient will bear, or until 100 ma. has been reached. It should remain for five minutes. When the current is turned off and an attempt is made to remove the intra-uterine electrode it will be found fastened to the tissues. A little movement to and fro and a gentle traction, however, will succeed in loosening it and it can be removed. Upon its surface will now be found a mass of white tissue, completely surrounding the electrode, the outer surface being tinged with blood. This is the coagulated albuminous secretion which has hardened from the acid action of the pole, and upon examining the cervical mucous membrane, it will be found completely denuded to the ultimate ramifications of the Nabothian glands. After this is accomplished, proper local applications can readily be made to the inflamed denuded tissues and cotton tampons adjusted to absorb the secretion. I employ a strong solution of chloride of zinc and carbolic acid (10 per cent. of each)

in glycerine in these cases. I know of nothing which will produce anything like the ideal effect in this perplexing difficulty which is obtained with not more than from four to six of these applications.

#### METRITIS OR HYPERPLASIA.

Metritis or hyperplasia is caused ordinarily from a passive congestion long continued, brought about by an interference of the venous return circulation from that organ by some form of displacement or from an irritation brought about from a torn cervix or an excessive or improper sexual intercourse.

A torn perineum may be the cause of a prolapse or a retroversion of the uterus. This will cause a bend in the broad ligament and an obstruction of the return circulation of the uterus, passive congestion results, hypertrophy follows, endometritis and uterine discharge develops. The cervix appears large, red and angry, the uterus to the touch is sensitive and upon pressure is painful. Dysmenorrhœa develops. The displacement with all the distressing accompaniments, may be the result of a displacement from violence, such as a fall, overwork, straining or lifting in a woman, who has not borne children. When a torn cervix is the cause of metritis, it is usually accompanied by subinvolution. The congestion is produced by the irritation caused by the unhealed cervix. The consequences are the same as when the cause is a displacement.

It must be clear here that we have a cause to remove, and then the disease, the result of the cause, to cure. A displaced uterus must be replaced, a torn perineum which is the cause of such displacement, must be repaired. A cervical tear must be repaired and united before a cure can be completed. When all of these rational details are borne in mind, then we can repair the damage; we can cure the metritis with galvanism better and quicker than in any other way.

The result sought in the treatment of this difficulty can only be accomplished by a remedy which will deplete the congested tissues, absorb the new formed tissues in the hypertrophied organ, and repair the mucous membrane by proper stimulation. Hence it can readily be seen how well combined we have these requisites, in strong doses of galvanism. The negative pole depletes by producing an active flow of fluids; the current of galvanism produces rapid absorption of the hypertrophied tissues by its interpolar effect, it stimulates the mucous membrane by its polar effect at that point, whether negative or positive.

#### APPLICATION.

Two distinct methods are recommended:

1st. Simple intra-uterine (negative or positive or both) galvanism.

2d. Negative galvano-puncture.

**The Intra-uterine Application.** When the uterus is greatly congested, employ at the beginning the negative intra-uterine application because of its depleting effect. A platinum, silver, gold or tin electrode is fitted to the uterine canal and connected with the negative pole of the battery, the circuit is completed by applying to the abdomen, an abdominal electrode. A current which will be easily tolerated up to 100 ma. can be employed with safety and benefit. Do not attempt to crowd the dose to the point of producing pain. The applications should be repeated as often as twice or three times a week, and each sitting should occupy about five minutes. The immediate effect of such a treatment is a sharp, burning sensation in the pelvis, which immediately subsides and leaves a feeling of tonicity behind and a free discharge of serum from the uterine canal. The remote results in such a case is a rapid subsidence of the congestion, a reduction of the uterus in size and the establishment of a healthy appearance to the cervix and endometrium.

If there is a hæmorrhagic tendency in the case, the treatment should be varied only in the employment of the positive pole instead of the negative. Also with deep cervical endometritic complications the positive pole should be employed as was indicated in considering the subject of endocervicitis. In a few cases where the negative pole is not well borne on account of its *katelectrotonic* effect, the positive should be substituted. In all other cases there is no occasion for employing anything but the negative pole.

**The Negative Galvano-Puncture.** This which is recommended by Apostoli in the treatment of chronic metritis, I have not employed. Under perfect technique it can have no other than a beneficial effect in these cases, as the puncture is exceedingly shallow.

A metal, sharp pointed electrode with a glass or celluloid shield which allows the active point of the instrument to protrude for two to four millimetres, is thrust into the angry congested cervix and is attached to the negative pole. The circuit is completed in the usual way and a current turned on of a strength varying from 15 to 100 milliamperes. The pain in this procedure is surprisingly slight. The current should be allowed to act for about five minutes. The application can be made with advantage once a week. Thus the depth of the puncture is very slight, easily healed, and the effect claimed for it by its adherents is one well calculated to induce one to make a trial of it in obstinate cases.

Metritis or hyperplasia are, under the ordinary forms of treatment, often difficult to manage to a successful issue. With the proper employment of galvanism their treatment is reduced to a science. Congestion and hypertrophy, with their consequences, pain, leucorrhœa and bearing down pressures, disappear gradually, but progressively, under the influence, while the whole constitution is toned by the action of the remedy on the circulation and the nervous system.

## SUBINVOLUTION OF THE UTERUS.

This condition, the result of some fault of nutrition which leaves the uterus in a state of enlargement following the escape of the result of conception, either at term or otherwise, is one for which a cure can often be obtained by the judicious employment of galvanism. It must not be supposed that the cause can in all cases be removed by this remedy, especially if it be a laceration of the cervix or perineum. Here, of course, we must not neglect our surgery if it should seem necessary after reducing the enlargement of the uterus. In all cases, too, we should combine our tonics with proper hygiene and seek earnestly by all means to remove the cause of the difficulty. The reduction of the uterus, however, regardless of cause, can, as a rule, be accomplished by galvanism, and if the cause of the failure of involution has long since ceased to exist, as is occasionally the case, a cure at once is effected.

In the reduction of the subinvolved uterus we employ the local effect of the negative pole and the inter-polar effect of the current, which includes the electrolytic effect and the heat producing effect. We also obtain the general tonic effect of galvanism, which is always excited by this agent when applied to the system.

An electrode of block tin, platinum, silver, or any other flexible conducting metal, is adjusted so as to fill the canal of the enlarged uterus. Our object then, after completing our circuit, is to give all the electricity the patient will bear without distress. If the uterus is 3, 4 or 5 inches in depth, the patient will frequently bear 150 ma., which is a pretty fair dose, and the maximum current employed should not much exceed that figure. Patients who will not bear this current must be given as near the limit of their toleration as can be without producing exhaustion. Five minutes of the maximum dose should be given as a treatment. It can be given with advantage every second day.

As the uterus begins to reduce in size and to assume its natural proportions, and the uterine canal area is lessened in consequence, the doses must be proportionately lessened. The maximum dose for a normal uterus will not exceed 50 to 75 ma.

The effect upon this class of cases is often most magical. The uterus will reduce rapidly in size. The old bearing-down pains gradually disappear. The pressure upon the rectum and the dragging upon the bladder ceases. The general health of the patient usually improves rapidly, appetite becomes normal, sympathetic pains, including sacralgia, headache and ovaralgia, are less frequent, and the menstruation, which as a rule has been rather profuse, assumes its natural condition.

#### INFLAMMATORY EXUDATES.

With inflammation any where, we have exudates, the purpose of which is to limit or circumscribe the progress of the fire. In the female pelvis, where the surroundings are organs of vital importance and where we have our only direct communication from the outside world into the sacred precincts of that great absorbing envelope, the peritoneum, protecting exudates following the smallest inflammation, are unusually abundant. Inflammation giving rise to these exudates is frequently relieved spontaneously or by surgical or medical interference. The exudate remains. Sometimes it, too, gradually disappears without treatment. In other cases it remains as a source of great irritation and distress to the patient, and unless relieved by some form of treatment becomes a permanent annoyance.

Electricity for a long time has been recognized as a valuable remedy in this difficulty. My own experience with it has been favorable.

The cause of the exudate does not matter so long as the cause is not acting. An active, acute inflammation only, contraindicates the use of the remedy. Pus without

present high temperature need not deter one from the careful use of galvanism. Much skepticism has been aroused among those who practice gynecology with the knife alone, by the claim of those who employ electricity as an additional remedy, that the absorption of inflammatory deposits and adhesions may be promoted by galvanism. As an abdominal surgeon, as well as an electrician, I wish to state emphatically that I believe such skepticism to be utterly without foundation. Inflammatory deposits may be and frequently are absorbed as the result of galvanism.

It is hardly necessary for me to describe these cases. They present themselves so frequently and with so many different complications to the general practitioner, as well as to the gynecologist, that they are well known. One comes with a general immovability of all the pelvic roof with the uterus fixed in its normal position; another with the uterus sharply retroverted or retroflexed with the fundus firmly adhered. Another with lateral displacements with thickened broad ligaments resembling tubular enlargements. While many others with slighter but none the less complicated symptoms are constantly observed.

Pain, with every degree of severity, is the prominent symptom of inflammatory deposits. Numbness and pain of the different areas of the lower extremities, as a result of pressure upon their nerve supply; difficulty in locomotion from interference with nerve supply to the muscles, or from restraining effect of severe pain caused by every effort to move such muscles; to say nothing of the many symptoms which find their origin in the pelvis, as a result of pressure, are of the many symptoms which must be carefully studied in every case of this kind.

Heretofore these cases have been the torment of the gynecologist. Hot water, glycerine, iodine and other stimulants, emollients, and alteratives have been the main remedies depended upon and their effect often after years of faithful application is hardly appreciable. From the un-

yielding disposition of this condition many pairs of perfectly healthy ovaries and tubes have been sacrificed with the presumption that there was pus in the tube, or interstitial inflammation of the ovaries. It is needless to say that the procedure is without effect except to modify the disturbance at what otherwise would be the menstrual period.

The object in treating these cases with galvanism should be to get the current to traverse the tissues containing the exudate. The negative pole should be employed for the active electrode and this electrode should be of the vaginal, rectal or intra-uterine variety.

If the vault of the vagina in the posterior *cul-de-sac* is the seat of the exudate, a vaginal electrode covered with moistened absorbent cotton should be pushed well up in the vaginal vault behind the cervix, and after the attachments have been made a current of 50 ma. should be employed for five minutes. If 50 ma. are not tolerated at the first few applications, give as near that dose as possible without transcending the toleration of the patient.

If the exudate completely surrounds the uterus a negative intra-uterine electrode may be employed, especially if there is some endometrium complication. The dose here should not exceed 50 ma.

The rectal electrode is employed very seldom. It is limited to the removal of exudates when surrounding the rectum or occasionally for a mass in the *cul-de-sac* of Douglas. 25 to 30 ma. is about the dose tolerated at this point and the pole should always be negative.

From three to six months treatment, the applications averaging three times a week, is usually sufficient time to accomplish the absorption of a very well marked inflammatory exudate. Until a fair trial is made of this treatment one is liable to be incredulous when they are told of the results which can really be accomplished.

One case which demonstrates the wonderful effect of

electricity in this direction, I will quote briefly, because the result was witnessed by others. It was in the Woman's Hospital, of Chicago, and was referred to me for treatment by Prof. W. H. Byford. It had previously been under his care exclusively. The woman had been treated for months by means of hot water, iodine and glycerine and general tonics, without the slightest improvement. The uterus was enlarged, retroverted and perfectly immovable from a thick, strong exudate surrounding the organ on all sides. The uterus could not be repositied by any means ordinarily employed. The woman was bed-ridden. Backache, constant pelvic pain, constipation and inability to walk were some of the prominent constant symptoms, with profuse and excessively painful menstruation as a periodical accompaniment.

In three months' time, by the employment of the means I have already described, in this case, the entire pelvic exudate had disappeared, the uterus had become movable and could be repositied and retained in place with a pessary, without the slightest discomfort. The patient now two years after treatment is in perfect health.

## CHAPTER XXI.

### UTERINE STRICTURES.

Stenoses of the uterine canal, are often met with which interfere with the normal functions of the uterus. They are congenital and acquired. The congenital is represented by the "pin hole os," and the cervical stricture from abnormal congenital antifixion. The acquired stenosis arises from inflammatory action caused by traumatism, or from cauterization of the endometrium, and may exist in any portion of the uterine canal, its predominating seat being the cervix.

Galvanism has long been recommended in strictures of the uterine canal, and for rapid, painless treatment of the difficulty, I know of nothing better. The acquired variety of stricture yields more readily to this agent, being caused by inflammatory action, but with careful management, all cases may be relieved.

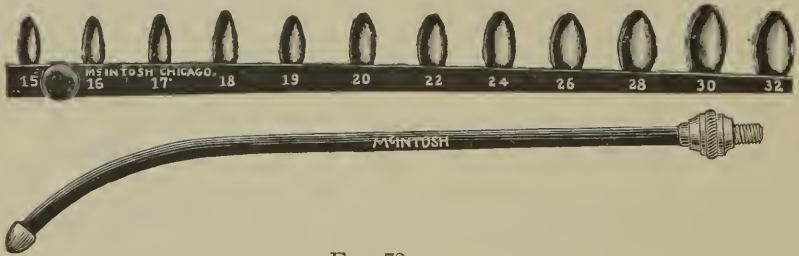


FIG. 72.

I employ for the active electrode in this work, a simply made urethral staff electrode upon the end of which can be secured bulbous metal points of any size required. By

heating the staff in warm water, it may be bent so as to conform with the direction of any canal. For an external electrode, a large sponge, membranous or clay electrode may be used.

*Method:* After carefully exploring the uterine canal and stricture with filiform bougies and determining its diameter, a bulb should be selected a millimeter larger in diameter than the stenosis, screwed to the staff, attached to the negative pole of the battery and inserted into the canal until it is stopped by the stricture. After placing the external electrode, attached to the positive pole, on the thigh or abdomen of the patient, a current of 20 milliamperes should be gradually switched on, while a steady pressure is maintained against the stricture by the internal electrode. Active electrolysis will occur at the negative pole, and the bulbous point will gradually traverse the stricture until it is passed. The electrode should then be carefully withdrawn, while the current is also gradually turned off. Care should be maintained to have an exact knowledge of the direction of the canal, so that by no possibility could an independent track be created which might lead the electrode through the uterine wall into the peritoneal cavity. At the next application the same procedure should be repeated, employing a bulb a size larger; the treatment should be given twice a week until the canal has been enlarged to the desired caliber.

With a pinhole os, a pointed acorn shaped tip may be employed while the cervix is carefully steadied with a tenaculum. Here, the external opening, only, is at fault, and often two or three passages of the stricture with successive electrodes, each a trifle larger, may be made with advantage at one sitting. With the pinhole os we have normal tissue to absorb in order to enlarge the opening, and a stronger current is consequently required. If, after a reasonable time, the electrode does not pass the stricture with a current of 20 milliamperes, gradually increase the strength to

30. Usually 4 to 6 applications will thoroughly absorb an ordinary stricture of the uterine canal. The superiority of results claimed for electrolysis for strictures of the uterine canal over dilatation, is the greater permanency of the former.

#### STRICTURES OF THE URETHRA.

The female urethra may be the seat of a cicatricial stricture, the result of traumatism. or of an infiltrated stricture, the result of urethritis. Electrolysis for the difficulty here, possesses advantages over gradual or rapid dilatation or cutting. The results from electrolysis are usually permanent, while from the three procedures mentioned above, there are frequent relapses.

*Method:* Employ the same form of insulated staff and metal bulbs as were described for the treatment of uterine stenosis. A bulb is selected which is a trifle larger than the first stricture. It is screwed on to the staff and the staff attached to the negative pole of a galvanic battery. The circuit is completed by the application of a sponge electrode, on the thigh of the patient, of the positive electrode. While the active electrode is passed into the urethra and the bulbous point is held firmly in the stricture, the current is gradually turned on until 10 to 12 milliamperes are reached. By firm, gradual pressure, the electrode will slowly dissolve its way through the stricture. When it has traversed the stricture or strictures into the bladder, it is cautiously and slowly withdrawn until it has repassed them, and then the current is switched off. At the next treatment, which should be in about three days, a bulb two sizes larger should be employed. The applications should be repeated at intervals of three days with larger and larger electrodes until the difficulty is completely eradicated. A current of sufficient strength to cause cauterization should never be used for stricture. When a sensation of severe pain follows the treatment, the current has been too strong.

## STRICTURES OF THE RECTUM.

Strictures of the rectum due to inflammatory infiltration, syphilis or cancer, may be relieved in almost all cases, and where not cancerous, may often be cured by the proper employment of galvanism.

Dr. Robert Newman, the father of electrolytic stricture treatment, reported to the American Medical Association in 1889, the result of his efforts in the treatment of strictures of the rectum in twelve cases. In summarizing, he said: "Eight cases were single strictures, four had multiple strictures. The duration of the malady was from six months to twenty years; the causes varied, but hæmorrhoids and constipation were important factors; other causes were syphilis, gonorrhœa, enteritis and dysentery. One case had the complication of five fistulæ, commencing in rectum and ending externally in different parts in vulva and gluteal region. As soon as the stricture was cured, the fistula healed up without any treatment. Only two cases had no previous treatment; two had medical and the balance surgical treatment; six of which had been operated upon with the knife. Not in a single case had the previous treatment been successful; some were entire failures, and all that can be claimed in some exceptional instances, was a temporary relief followed by a relapse. The three cases 5, 6, 8, were certainly improved, but in the end may not prove satisfactory; one patient had too many complications, and while I have not heard from her, I know she could not have been permanently benefited; the second was an aggravated case, and the patient too poor to attend to herself, or even to come regularly for treatment. This case was then operated upon, and she had to use a rectal bougie regularly, by which means she kept the stricture from closing up again; but after four years, had a relapse with complications, and finally died. The improvement in the third case (No. 8), has been graciously acknowledged by several surgical

authorities: however, the patient had to leave the city, thereby interrupting the treatment, and a papillomatous growth, which by some was considered cancerous, complicated the case to such a degree that a cure could scarcely have been expected under any treatment. These cases are given just as they were, without claiming any success. The remaining nine cases, however, were cured by the electrolytic treatment, and as far as known, no relapse has taken place, in from one to ten years respectively; except one case from which nothing has been heard." Dr. Newman, in his conclusions states that "the best chances for a cure are with the fibrous and inflammatory strictures."

The author has had some experience in the treatment of stricture of the rectum by galvanism. Inflammatory strictures can be painlessly dilated by means of a negative electrode bougie, when the ordinary rectal bougie has failed to give satisfactory results. While malignant stricture cannot be cured, the caliber of the bowel may be maintained sufficiently large, by means of the proper employment of galvanism, so that surgical procedures may be avoided. As pressure is contraindicated in the use of electrical bougies (electrolysis being relied upon to enlarge the canal) there is not the same danger of rupturing the bowel where the cause of stricture is carcinoma as with ordinary dilatation. Galvanism, too, acts almost as a specific for the pain caused by carcinoma in this trouble.

*Method:* A strong flexible metal staff insulated with hard rubber, upon the end of which may be screwed olive metal tips of varying diameters, should be employed as the active internal electrode. (Fig. 73.) A large flat hand, or a



FIG. 73.

small clay electrode should be employed as the external or passive electrode.

The caliber of the stricture should be ascertained by means of flexible bougies. A metal bulb should be attached to the staff of the internal electrode with its great diameter one millimetre greater than the diameter of the stricture at its smallest point. The staff should then be attached to the negative pole of the battery, the electrode carefully inserted into the rectum with the point of the bulb engaged in the stricture, with the circuit completed by applying the positive pole to the thigh or abdomen, the current should gradually be turned on until it reaches a strength of 20 to 25 milliamperes. The operator, meanwhile, with a firm hand, guides the electrode, as it gradually dissolves its way through the stricture. After it has passed the stricture it is gradually withdrawn and the current turned off. Strong pressure should not be employed. Five to ten minutes is frequently required to pass an ordinary stricture with an electrode which is but a millimetre larger than the estimated caliber of the bowel. Applications can be made as often as every second day, and with advantage as seldom as once in two weeks. The electrodes should be increased in size as the caliber of the stricture warrants until the desired enlargement is accomplished. As the bulb of the electrode is increased in size in the progress of the treatment, the current can be proportionately increased, so that with an electrode of two or three centimetres in diameter a current of from 30 to 40 ma. can be advantageously employed.

#### HÆMORRHOIDS.

I quote the following from an article by Prof. J. B. Bacon of Chicago, on hæmorrhoids. I have watched his work and therefore can recommend the method in selected cases.

“The use of electricity for curing fibroid tumors of the uterus having been a decided success in selected cases, many surgeons have recommended it as a curative agent in the treatment of hæmorrhoids. Although statistics are

not very complete, and the number of experiments made are not numerous enough to warrant one in pronouncing electrolysis in hæmorrhoids a sure cure. yet the reports of French, English and American authorities are sufficient to encourage us in carrying the experiments further and proving or disproving its usefulness.

“I have been trying the method both in private and dispensary practice but a comparatively short time, and in every case it has caused a decided decrease in the size of the tumors, and in no case was there any secondary hæmorrhage or sloughing or after-pains,—conditions certainly in its favor.

“The pain at the time of treatment is slight when applying it to internal hæmorrhoids, but its use for the external variety causes so much pain, especially while the current of electricity is turned on, that an injection of cocaine into the tumor as a preparatory measure is imperative.

“The old method of using electricity for curing hæmorrhoids was to have the patient take the positive electrode in his hand while a needle connected with the negative electrode was inserted into the tumor and sufficient current turned on to produce a decided cauterizing effect—the treatment lasting from five to ten minutes. This method was not approved on account of the severe pain, especially increased by the distance of the electrodes.

“It has been well established experimentally by dermatologists when removing moles, superfluous hairs, etc., by means of electricity that the pain is decidedly lessened if both poles are in proximity when the current is turned on, and in most cases the use of cocaine was thereby rendered unnecessary. With this idea in view I have had an instrument made by the McIntosh Battery Co. of this city that has proven to work quite satisfactorily. It consists of a long pair of forceps similar to urethral forceps, (Fig. 73 A.) insulated with vulcanized rubber except at a place about one-

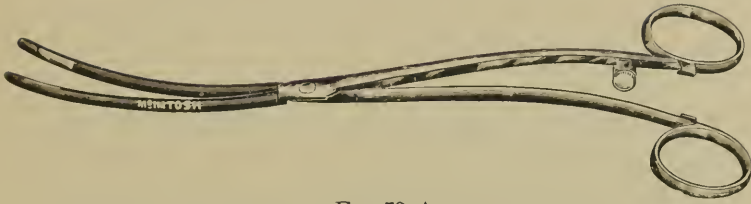


FIG. 73 A.

half inch long on the face of the blades. On the handle of the forceps is a set-screw to fasten the wire leading to the battery.

“The instrument is used for the positive pole and the hæmorrhoid is seized with the forceps in such a manner as to have the exposed metal of the blades clasp it at its base, when it can be steadily held or drawn down so as to expose it to view while operating. The negative pole is connected with a disk or needle holder, and I prefer one containing at least four needles. (Fig. 73 B.) After grasping the hæmorrhoid



FIG. 73 B.

with the forceps, a few drops of a four per cent. solution of cocaine are injected into the tumor, after a few minutes waiting for the anæsthetic effect of the cocaine the needles are pushed into the center of the tumor and an assistant turns on from five to ten milliamperes of current. Immediately there will be noticed an escape of hydrogen around the needles, and a decided blanching of the hæmorrhoids. The current should be kept up until the tumor becomes a whitish-gray color, usually requiring from two to five minutes time.

“Microscopical examinations of hæmorrhoids prove them in many cases to be real tumors resulting from original varicosities of the veins that have, through inflammation and rupturing of the vessel walls, left trabeculæ of fibrinous tissue interlacing through its center. Other

hæmorrhoids are composed of arteries and capillaries, in addition to the veins.

"The current between the electrodes canterizes by electrolytic action in this tissue composing the tumor, resulting in its ultimate absorption.

"There are some points necessary to observe in using electrolysis in this class of cases:

"1. Give an enema and thoroughly empty the colon before operating.

"2. Disinfect the tumor before introducing the needles, and again after the operation.

"3. Never use this method in acutely inflamed hæmorrhoids.

"4. Do not use over one-sixteenth of a grain of cocaine hypodermically.

"5. Always insert the needles into the tumor before the current of electricity is turned on, and have the assistant again turn the current off before withdrawing the needles.

"6. Use a milliampere metre for measuring the strength of current, as it is impossible to estimate the varying resistance of the tissues in different cases.

"7. The needles may be a direct source of infection in the hands of a careless operator, and they must be boiled before using."

## CHAPTER XXII.

### GALVANISM FOR CANCER.

Carcinoma has been successfully treated in two ways by galvanism.

1. By the uninterrupted galvanic current.
2. By the interrupted galvanic current administered in strong doses.

#### (1) UNINTERRUPTED GALVANIC CURRENT.

Drs. Neftel, Robert Newman and Beard and Rockwell may be said to be the pioneers in this method of treatment.

The method consists in the employment of needles at the negative pole which are thrust into the cancerous tissue or through the healthy tissue at the base of the diseased tissue and employing a large indifferent electrode of sponge, clay or absorbent cotton, at some convenient distance away from the tumor, and then turning on a current of sufficient strength to produce active electrolysis at the needle electrodes. Needles are employed at both poles by some operators.

**Cancer of the Cervix Uteri.** A localized cancer of the cervix should be treated as follows: After exposing the cervix with retractors the organ should be transfixed at the



FIG. 74.

base of the disease with from three to four strong, half curved surgical needles, to which, by means of a divided cord (Fig. 74), should be attached the negative pole of a

galvanic battery. Upon the surface of the abdomen should be placed an indifferent electrode of clay, membrane or absorbent cotton attached to the positive pole. A current should then be turned on of a strength of 100 to 250 milliamperes. Such a current in itself can be tolerated without an anæsthetic, but the pain of the transfixing of the cervix may frequently require one. The needles should be insulated from the vagina by dry cotton or soft rubber. The current should be applied for ten minutes. That active electrolysis occurs at the needles is demonstrated by the white foam gathering at the points of insertion and the rapid discharge of gas bubbles. If the cancerous tissue is extensive so that the needles allowed at one operation are not sufficient to undermine it, a second sitting (employing the needles in fresh tissue) should be resorted to.

The primary effect of this treatment is to cut off the nutrition of the new growth by undermining it, while the secondary effect, claimed by a few, is a specific influence on the cancerous development which checks its growth.

If the cancer has developed into the body of the uterus, and there is reason to believe it has extended into surrounding tissues so that it cannot be thoroughly removed by a vaginal hysterectomy, electricity may be employed as a forlorn hope, as a *placebo*, or for its sedative effect. Here the negative needles may be thrust into the mass of the uterus and the same details followed otherwise as described for the treatment of the cervix. I have seen great relief obtained and, I am sure, life prolonged, by the intra-uterine applications of the positive pole with strong currents in far advanced cases. The excruciating suffering experienced with this disease, certainly is markedly ameliorated by galvanism.

Dr. Robert Newman favors mild currents from 20 to 50 milliamperes rather than stronger currents from 50 to 250. My experience makes me have greater confidence in the strong doses.

I have given in detail the treatment for cancer of the cervix and must leave the reader to apply the details described there in treating cancer in other gynecological cases, as the vulva, the rectum and the breasts. Needles from the negative pole, one or several in number, according to the extent of the disease, should be thrust into the diseased tissue and the circuit completed by means of a large surface electrode at some distance, or by means of needles attached to the positive pole. If it is considered desirable to employ needles at the positive pole they should be constructed of platinum or some other unattackable metal.

(2) BY THE INTERRUPTED GALVANIC CURRENT—PARSONS' METHOD.

Dr. J. Ingles Parsons in 1889 described a method of treating cancer which was decidedly new. (*Lancet* Nov. 30, 1889.) "The patient is anæsthetized; the current is then passed through the tumor and the tissues for some inches round it by means of fine insulated needles so as not to injure the skin. A battery of galvanic cells with an electromotive force of 105 volts is used. The intensity of the current, to commence with, is ten milliamperes, gradually increased to 600 milliamperes and flashed through the growth in every direction from 50 to 100 times, according to circumstances. The pulse and respiration are carefully watched. One out of four cases treated (a woman aged 63, with extensive carcinoma of the left breast, a presystolic bruit and weak intermittent pulse) was unable to stand more than 250 ma., and for this reason—when the current is applied to the left breast electrical stimulation of the heart occurs, and if this organ is healthy an increase in the strength of its contractions appear to take place after its passage; but with the patient who had cardiac disease, the improvement only continued up to a certain point and then intermittently increased and great irregularity occurred. In a secondary

growth in the axilla in the same patient, a current of 600 milliamperes could be tolerated with perfect safety."

"The effects produced by the action of the electricity consists in a cessation of growth, gradual disappearance of pain, some shrinking and hardening of the tumor, and enlarged glands, followed by improved nutrition and a better state of the general health. The growth as a whole does not disappear, but remains as an inert mass composed in all probability of fibrous tissues alone."

The advantages, as summarized by Dr. Parsons, are as follows: (1) There is no destruction to the normal tissues of the body, and if recurrence should at any time take place its progress can be immediately stopped and the treatment repeated as many times as necessary. Life, by this means, may be prolonged indefinitely, provided the metastatic deposits had not occurred before the commencement of the treatment.

(2) Patients are not obliged to lie up for more than a day or two as a rule. They lose no blood and are not generally any weaker. (3) The current can be passed through almost any part of the body and thus arrest growths which could not by any possibility be otherwise treated.

There are now on record in the literature a number of well-authenticated cases of cures by the Parsons' method of treatment. Of course it is yet too early to say that these cases will be permanent. Electricity is a potent remedy, and by Dr. Parsons it is administered in powerful doses and the trial of his treatment will be watched with keen interest by the profession.

## CHAPTER XXIII.

### FARADIZATION.

In gynæcology, the secondary or induced current, has a wide field of application. Two distinct physiological actions of the current are recognized and utilized. An induced current from a secondary coil constructed of short, coarse wire, has a marked effect in producing muscular contraction. As this short, coarse wire gives but slight resistance and allows a current of comparatively large amperage to flow, it is called the current of quantity in contradistinction to that which is induced in the long, fine wire which is called the current of tension. The current of tension has a marked anæsthetic effect, and consequently is employed in gynæcology to relieve pain.

Unfortunately, as yet, we have no means of measuring the faradic current. We have not even a uniform standard for battery construction. The only way that results can be estimated at present, is for each operator to describe the apparatus which he employs, and the method of regulating his current. A committee was appointed at the first meeting of the American Electro-Therapeutic Association at Philadelphia, in 1891, whose duty, among other important things, it is to recommend a faradic battery which may be adopted, by universal consent, by all physicians.

The battery employed in Gynæcology by Apostoli and his immediate followers, is described by Dr. Laphorn Smith, as follows: "The short wire coil, which is about twenty-five yards long, and No. 14 or 16 in diameter, is insulated with silk and varnished between the layers. The

fine wire is about No. 40, which is the finest made, and is about a mile long.\* Dr. Augustine H. Goelet recommends the Engelmann faradic battery (Fig. 32) as the only reliable apparatus suitable for gynæcological work, which is manufactured in this country.† In this the coils are arranged as follows: "The secondary coarse wire coil is of No. 16 wire, about 75 yards long; the intermediate is No. 22 wire, 225 yards long; and the fine wire coil is of No. 32 wire, about 660 yards long." Dr. Goelet, while admitting this battery a great improvement upon the old form of apparatus, makes the just criticism that the coils do not wholly meet the requirements of gynæcological work, since very sensitive conditions cannot bear the current from the finest coil. By employing a rheostat with the latter coil when necessary, the above objection is obviated.

#### ELECTRODES.

There are two methods of applying faradization. First, by employing two distinct electrodes with the poles separated, one as the active electrode intra-uterine or intra-vaginal, and the other as the passive electrode, placed at some convenient location on the surface of the body—as in the employment of galvanism. This is called the *unipolar method* because but one pole is made active. Second, by employing an instrument which combines the two poles in such a manner that they both become active; each coming in direct contact with the tissues to be affected. This is distinguished as the bipolar method.

For the unipolar method, the same form of electrodes may be used as the active electrodes as those employed in applying galvanism. For the bipolar method very different instruments are required.

The vaginal bipolar electrode is shown in (Fig. 75).

\*Med. News Jan. 25th, 1890.

†American Electro-Therapeutic Association, 1891.

The two metal surfaces on the instrument, represent the two poles and are independently connected with the two binding posts at the proximate end of the electrode. While



FIG. 75.

the two poles are thus combined in one instrument, they are completely separated with insulating material, and the circuit is completed only when the two metal areas on its surface come in contact with the tissues of the vagina.

The intra-uterine bipolar electrode (Fig. 76) is constructed



FIG. 76.

ed on the same principle as the vaginal bipolar instrument. It is essentially a double electrode, with the two poles separated a distance of two to four centimetres. When it is inserted into the uterine canal, the uterine tissue alone completes the circuit, thereby limiting the effects accurately to a given area. Fig. 77 shows the author's flexible bipolar electrode.



FIG. 77.

**The Unipolar Method** is employed when it is desirable to affect tissues at some distance from the cavities of the pelvic organs, as the round ligaments, or the ovaries, or tubes; especially when a more or less general tonic effect is desired. It is occasionally employed in connection with general faradization, when, in conjunction with an atonic

condition of the pelvic organs, there exists a general neurasthenia.

**The Bipolar Method** is almost universally employed in pelvic faradization. It is indicated in all forms of localized pelvic pain, as a much stronger current can be borne by this method than by that which requires one pole to come in contact with the skin. For the same reason it is preferred in cases of purely pelvic muscular non-development. Dr. Laphorn Smith, writing on this subject, summarizes the advantages of the bipolar method as follows:

1. "It is less painful than the old method, because it does not require the current to pass through the skin, which is much more sensitive than the vagina."

2. "It is easier to apply because it dispenses with the need of an assistant."

3. "It allows a much stronger current to be tolerated."

4. "It is consequently more effective, because the higher the intensity of the dose, the more marked the effect."

Faradization is indicated in gynæcology, as may be inferred from its physiological effects, in (1) Muscular non-development, (2) Muscular atrophy and relaxation, (3) Pain.

#### MUSCULAR NON-DEVELOPMENT.

**Non-development of the Uterus.** This condition, characterized by a flabby tubular state of the organ, with elongated cervix, infantile anti-flexion, scanty menstruation usually accompanied with severe pain, is promptly improved by the systematic employment of intra-uterine bipolar faradization from the coarse wire. The intra-uterine bipolar electrode is carefully inserted to the bottom of the uterine canal. This can ordinarily be accomplished without the necessity of employing a speculum, a point of value, as the physician is frequently called upon to treat this condition in unmar-

ried women. When, because of flexion or any other reason, the electrode cannot be inserted in this way, employ a small Sims' speculum, straighten the uterine canal by drawing on the cervix with a tenaculum, and the electrode can be easily introduced, after which, the tenaculum and speculum may be withdrawn. After the electrode is in place, attach the two terminals of the battery to the two binding posts of the electrode, and commencing with a light current, gradually increase it until the limits of toleration is reached. The seance should last for ten minutes. The current should then be gradually turned off. The treatments may be given with advantage as often as every second day, and may require from weeks to months to accomplish a complete development of this organ, according to the general physical condition of the patient and the success obtained by the physician in maintaining, by means of tonic and good feeding, a normal state of health.

**Non-development of Vagina.** An undeveloped vagina has the characteristics of an infantile organ. It is small, sensitive, smooth, and without normal secretions. The muscular tissues can be developed by applying faradization from the coarse coil. A small bipolar vaginal electrode should be inserted into the vagina, and after making connections, a current as strong as the patient will bear without pain, should be switched on and allowed to act for ten to fifteen minutes. The applications can be made as often as three times a week. The treatment, necessarily, from the nature of the condition, should continue over several weeks.

**Ovaries and Tubes.** Infantile ovaries and tubes are beneficially affected by this stimulating current. This condition, which ordinarily accompanies non-development of the uterus and vagina, may some times exist independently. The symptoms are usually scanty and painful menstruation. The pain is of a dull character, and is liable to precede the flow for a number of hours, continue throughout and remain

to gradually subside some time after the discharge ceases. The application of the stimulating current here, may be either bipolar or unipolar. If the bipolar method is chosen, the intra-uterine electrode should be selected, as it reaches nearer the tissues to be stimulated. The same procedure should be adopted as for stimulating the uterus, except that it may be allowed to act for a longer time at a sitting—as fifteen to twenty minutes. If the unipolar method is employed, an ordinary intra-uterine electrode may be selected, or a vaginal electrode with half insulation (Fig. 78) with, in either



FIG. 78.

case, a large hand sponge electrode placed on the abdomen for the indifferent instrument. When the unipolar method is employed, the two electrodes should be placed in such position that the organs to be effected, should lie between them. In this way, they occupy the field of electrical action, and must get the benefit of it. The current here, should be as strong as the patient can tolerate without pain, and the application last for ten minutes.

#### MUSCULAR ATROPHY AND RELAXATION.

Atrophy of the muscles of the organs of the pelvis, frequently occurs and leaves a patient in about the same condition that exists with non-development of the same organs. The treatment is practically the same.

**Atrophy of the Uterus.** Here the bipolar intra-uterine electrode should be employed with the stimulating current from the coarse wire. The current should be as strong as the patient will bear without pain or discomfort, and the treatment should last for ten minutes. General tonics should not be neglected, and an effort to discover and remove the cause, should be instituted.

**Atrophy of the Vagina** should be treated in the same manner as non-development of that organ. (See page 212.)

**Atonic Rectum.** This condition, so frequently found in women of indolent habits, and in those, who have for different reasons allowed the rectum to become repeatedly dilated with accumulated feces, is one which may be greatly relieved by means of the stimulating effect of the coarse wire induction. It must be pre-supposed that a physician has given explicit instructions to a patient in regard to the future regulation of her habits. The cause of the existing condition must be found and removed. If there is a torn perineum or a displaced uterus to be restored, they should be attended to at once. If the diet is imperfect, it should be perfected. If the exercise is deficient, it should be carefully remedied. Faradization will only restore the parts to health when its action is untrammelled.

Inaction of the bowels here, is caused by an atonic condition of the muscular coat from thinning of the muscles from inordinate distention. The treatment in these cases can be given with advantage every second day. The bowels must be kept empty; so that the organ will be in a condition to take advantage of all muscular development gained by the stimulation. A bipolar rectal electrode may be used, or the ordinary rectal electrode (Fig. 79.), with an indiffer-



FIG. 79.

ent one of sponge placed upon the abdomen. If there is reason to believe that the atonicity is confined to the rectum, the bipolar method should be preferred. The current should be as strong as the patient will bear agreeably, and the application should last fifteen minutes.

If there is an atonic condition of the whole lower bowel, or of all the bowels, the unipolar method should be employed. In this case the rectal electrode should be inserted

and attached to one pole of the battery, preferably the positive, and the other electrode, which is to be placed upon the abdomen, should be attached to the other pole. A current as strong as the patient can bear without pain, should be given. An attendant may, with advantage, during the treatment, slowly move the external electrode over the abdomen in the line of the large bowel. The effect of systematic faradization applied in the manner described, for inactivity of the bowels caused by atony, is some times almost marvelous.

**Relaxation of the Supports of the Uterus.** Prolapse of the uterus without previous traumatism implies relaxation of ligaments or muscular supports. The perineum muscles, the muscles forming the vaginal column, the muscles of the rectal tube, the few fibers in the recto-uterine ligaments, those of the round ligaments, and the vesico-uterine ligaments, are all concerned in maintaining the uterus in its normal position. Whatever may have been the determining cause of a uterine displacement, if muscular relaxation or atrophy is the only one existing, it can be cured by the proper use of the stimulating faradic current. If the weakness is in the uterus itself, or its ligaments, the intra-uterine bipolar treatment should be systematically employed. If the relaxation is perineal or vaginal, the bipolar vaginal instrument should be selected. If the muscular relaxation is of a general pelvic character, the treatment should be the unipolar variety, or an alternating of the bipolar between the uterus, vagina and rectum.

**Subinvolution of Uterus and Vagina.** Dr. Lapthorn Smith and others, employ the coarse wire stimulation of the faradic current for subinvolution of the uterus and vagina. It is rational to expect good results in this condition. Dr. Smith says: "Subinvolution means deficient contraction; electricity supplies what is wanting, by setting up contractions, at first temporary but afterward permanent; the blood

vessels are diminished in size, and the organ becomes smaller, lighter and less vascular."

A bipolar intra-uterine electrode should be employed with the maximum current tolerated without pain. Application, ten minutes; frequency, every second day.

**Postpartum Hæmorrhage.** Faradization, and especially the coarse wire current, is one of the most reliable, prompt and harmless means we have for causing immediate contraction of an atonic postpartum uterus. It may be utilized in three distinct forms. 1st. Bipolar intra-uterine; 2d. Unipolar—with one pole in vagina or uterus, the other on the abdomen over the tumor; 3d. One sponge electrode over sacrum, the other over abdomen on the uterine tumor.

The most reliable method is the first. The objections to it is the necessity of inserting an instrument into the uterine cavity. This will not hold good, however, if the electrode is rendered aseptic before it is used. After it is cleaned, an ordinary bipolar vaginal electrode of small size should be guided into the uterine cavity. When it is in place, the current should be turned on until the patient complains of pain, or until the uterus is felt to be rapidly contracting. The current should be allowed to act until the uterus has firmly contracted, when it can be turned off, while the accoucheur watches the result. If there are symptoms of relaxation, it should be immediately reapplied. This should be kept up until the attendant is satisfied that the difficulty is permanently controlled.

The second method is very efficient, and may be employed with any ordinary battery if the coarse wire coil is not at hand. Insert, after using the ordinary aseptic precautions, an ordinary vaginal electrode into the vagina, attached to one pole and place upon the abdomen a hand sponge electrode attached to the other pole, while pressing the hand electrode firmly over the uterine tumor gradually switch on the current. The uterus will rapidly contract under the hand.

By the third method no electrode is inserted into the puerperal track. While the method is not so prompt and reliable as the other two, it will often accomplish the result. One electrode in the form of a sponge, is placed over the sacrum, and the other of the same construction is placed on the abdomen, over the uterine tumor. The current is then applied until the desired results have been obtained.

#### PAIN.

For pain, the fine wire induction coil is employed because of its marked anæsthetic effect. If the unipolar method is employed, the active pole, which should be placed at or near the seat of pain, should be positive, as it is more sedative than the negative. The bipolar method, however, is almost always applicable for pelvic pain, and on account of its greater convenience, is preferred to the unipolar method.

Dr. Laphorn Smith, who has had much experience with the faradic current, has found four conditions in which the fine wire current acts beneficially. They are:

1. "Ovarian pain where no organic disease could be found. The first sitting should last ten, twenty, or even thirty minutes if it is that long before the patient can say that her pain has gone; it is then well to tell her that she may expect the pain to return after a few hours, but that each day it will stay away longer, and longer until after a variable number of sittings, rarely more than ten, the pain will remain away altogether."

2. "In cases of abdominal pain, due to hysteria, it acts promptly, not only in rendering the abdomen insensitive to pressure, but also in calming the general nervous crisis within a few minutes."

3. "There are many women about the age of thirty, who, though fleshy and apparently well supplied with blood, do not menstruate at all, or but slightly. These women feel uncomfortable; their *embonpoint* makes them

weak, and they have many nervous symptoms, which places them in the category of hypochondriacs. Any thing that will bring on a full return of the menstrual flow, gives them immense relief. I know of nothing that will attain this object more surely than three applications a week of the current of tension to the inside of the uterus between the periods. Not only will the flow be re-established, but the uterus, which before measured less than normal, will soon develop to its full size."

4. "In vaginismus, I have found it remarkably effective." Dr. Apostoli has advocated a fifth indication with which Dr. Smith adds: "I have not had experience, viz: In pelvic pain due to inflammatory conditions of the uterus or its appendages." "Those who wish to try it will do well to remember Apostoli's warning, not to push the strength of the application beyond the point which can be easily borne, while on the other hand, in pelvic pain of non-inflammatory or hysterical nature, it is some times an advantage to push the current rapidly until its full strength is turned on."

**Method of Application:** The same directions should be followed as for the administration of the coarse wire current. For ovarian or uterine pain, the intra-uterine bipolar electrode should be employed. For vaginismus, a small bipolar vaginal electrode is suitable which may be increased in size as the trouble yields.

## CHAPTER XXIV.

### STERILITY.

Sterility a symptom, and one the cause of which is not always confined to the patient seeking relief, is a condition which must be treated through its causes. Those which may be successfully dealt with by electricity may be enumerated as follows: Vaginismus, non-development or atrophy of the uterus, non-development of the tubes and ovaries, acute uterine flexions, uterine stenosis, and chronic cervical catarrh.

Sterility caused by vaginismus or sensitive and irritable vagina, which prevents normal cohabitation may frequently be relieved by the employment of fine wire faradism (see p. 210) by means of a small bipolar vaginal electrode. A few applications have been known to cure the difficulty. The operator should commence with a light current, and gradually increase it from day to day.

Sterility caused by non-development or atrophy of the uterus, tubes and ovaries should be treated by a systematic course of coarse wire faradism, as described in treating of those conditions in another chapter (p. 211). It may be necessary to treat these cases for several months before the organs may be said to be thoroughly developed. When acute uterine flexions result in sterility the muscular tone of the organ should be developed by using the coarse wire induced current.

Uterine stenosis, a frequent cause of sterility, is treated of at length in the chapter devoted to that subject. The negative pole of the galvanic current is employed with an

intra-uterine staff terminating in an insulated bulb. These bulbs are different sizes, and by electrolytic action the canal is gradually enlarged by their successive employment. Besides enlarging the canal and overcoming the stenosis, a salutary tonic effect is produced on all the pelvic organs by the galvanism.

Chronic inflammation of the cervical mucous membrane and the deep Nabothian glands, giving rise to the characteristic tenacious albuminous discharge, is a frequent cause of sterility, by its obstruction of the mouth of the uterus. This condition, as was described on page 189 may be effectually cured by the aid of the positive intra-uterine pole of the galvanic current. An electrode is selected which fills the cervix, and when inserted is attached to the positive pole; after the circuit is completed by applying an abdominal electrode, a current of 50 to 75 milliamperes is turned on and allowed to act for five minutes. When an attempt is made to remove the internal electrode, it will be found firmly attached to the secretion of the canal, which has become thoroughly coagulated. A little tension removes the electrode with the adherent mass of secretion, to the ultimate ramification of the deep glands. The exposed, clean, mucus surface can now be treated, and after a few such applications the cervix will be cured.

## CHAPTER XXV.

### 'THE S. WEIR MITCHELL TREATMENT FOR HYSTERO-NEURASTHENIA, OR NERVOUS EXHAUSTION OF WOMEN.

Hystero-neurasthenia is a name that I gave several years ago to an often recognized class of female difficulties which has not a well-defined place in medical literature.

The symptoms of this class of cases are as difficult to enumerate and describe as the individual cases are difficult to manage to a successful issue. Under the term hystero-neurasthenia, I wish to include no symptoms which can be traced to a distinct pathological lesion of any one organ, but to a host of symptoms that can be accounted for in no other manner than by being the result of a partial or general nervous inefficiency, or perversion, of the nerves controlling the organs peculiar to women.

The first of these conditions, nervous inefficiency, may be congenital, or the result of excessive exercise of the functions of the organs of the pelvis, from a long and prolific child-bearing season, excessive cohabitation, or undue treatment of a local variety. The second condition, nervous perversion, will be found the result of excessive brain work, either as a consequence of early study, or from literary excess, teaching, and clerical work common to women of maturer life, the worries of motherhood, anxieties of impending or actual misfortune, prolonged lactation, nursing of the sick, excessive physical labor, and rarely masturbation.

The symptoms of this class of cases are too numerous to mention in detail, and inasmuch as each case has its own

<sup>1</sup>The substance of this chapter was read before the Chicago Medical Society, March 7, 1887.

peculiarities, I will remain content to recite a few of the most prominent and common symptoms. General anæmia, or deficiency of red corpuscles, is a very common, but not universal symptom. The anæmic cases usually complain of loss of flesh, although it is well known some anæmic patients gain flesh; and where this state of affairs exists the functions of the generative organs usually suffer, as is often manifested by coincident amenorrhœa and sterility. Upon questioning these patients the keynote of a general outpouring of subjective symptoms is struck, when the womb is reached in the list of interrogations—bearing-down pains, backache, leucorrhœa, neuralgia in ovarian region, painful menstruation (pain before menstruation, during the flow, and for days following), frequent urination, constipation—“bowels never move without medicine”—painful defecation, neuralgia in all parts of the pelvis at regular or irregular intervals, in the ovarian region, one or both sides, uterus, vagina, bladder, perineum, rectum, and even the urethra. Standing and walking is accomplished very seldom without fatigue, and scarcely less rarely without pain in the loins and lower pelvic region.

These sufferers usually have worn out the patience of one or two physicians; many times are pronounced hysterical incurables, who imagine many of their aches and are therefore considered unworthy of more dignified attention than that required to prescribe an anodyne, a hypnotic or a blister. These cases are much too interesting, and the credit of effecting a permanent cure of too much gratification, to say nothing of duty, for us to be satisfied to listlessly alleviate symptoms, when it lies in our power to do more.

Upon physical examination this class of patients present few well-marked subjective symptoms. There is no evidence of hereditary taints. As this trouble is referred to the uterus, the first local examination is made of the pelvic organs. The vulva is often pale in color from general

anæmia. The mucous membrane within the vagina presents a faded, lax appearance. The external genitals are sometimes bathed with mucus secretion from the relaxed vulvo-vaginal glands. The vagina is often sensitive, bathed with mucus frequently; at other times abnormally free from secretion. The uterus is normal in size and location, with perhaps the exception of slight prolapsus from the general relaxation of all the surrounding parts. It is very movable, as a rule. The organ is very liable to be marked by hypersensitiveness on pressure. A slight mucus discharge from the cervix, of a milky character, is rarely absent. The cervix is usually pale in color. Pressure in the ovarian region causes pain, or at least a feeling of sensitiveness; the ovaries can be frequently engaged between the hand placed over the relaxed, thin abdominal walls, and the index finger in the vagina, and will often be found considerably enlarged. The *rectum* is rarely found in other than a relaxed condition. There is frequently much tenderness about the anus, with slight nodular enlargement of the external hæmorrhoidal veins. Fæces are often found in the lower bowel. The bladder is often sensitive to slight pressure, and not rarely, where the patient is anæmic, there will be a pouching of its neck. The urine is pale, and commonly filled with phosphates and mucus. Upon manipulating the abdominal wall there is scarcely a point that does not seem most sensitive, except, perhaps, the ovarian region. The muscles are flabby and relaxed upon the limbs, although occasionally covered with soft fat.

The heart action in these cases, while not strong, is usually regular. The exception to this is in very nervous patients where, through sympathy of a rebellious or weak stomach, palpitation and heart-burn will be a complication. The capillary circulation is frequently slow, as evidenced by the slow return of the circulation to a part deprived of its blood by pressure of the finger.

The digestion is often fair, but rarely very good. At-

tacks of nausea are frequently complained of, coming on without any warning and disappearing in the same way. Occasionally, downright attacks of indigestion are experienced, which may not be confined to the stomach, but affect the whole digestive tract. These attacks may be accompanied with headache. Spinal tenderness in one or more regions is often present; this will frequently be found quite marked in the lower dorsal or first lumbar region.

Besides the symptoms enumerated, which can be said to rank under the head of hystero-neurasthenia, we may have, in addition, all the symptoms that are common to general neurasthenia, the special symptoms about the pelvis determining the disease, because of their greater prominence and severity. While we have found by general examination of these cases, both subjective and objective, not one organ in the pelvis or abdomen in vigorous health, and not one free from weakness and tenderness, we have not found an actually diseased member—that is, diseased from any pathological condition peculiar to itself, but rather from a general lack of balance between supply and demand in the nutrition of several. And while it is rare for a single case to present all the symptoms above noted, occasionally, as many of us can testify, *all* these and others will manifest themselves in their most aggravating form in one suffering individual.

Though no exact pathology of these cases has been definitely demonstrated, except through the deductions drawn from successful treatment, the fault is generally conceded to lie in a weakened or incomplete state of that part of the nervous system which presides over the nutrition of the organs involved. A general malnutrition, then, of the parts implicated is that toward which we must direct our treatment. As these patients always complain of being tired, the first indication for treatment is rest. As they are almost invariably anæmic, proper feeding is the second indication. As a case is rarely found in which nervous

debility is not the rule, seclusion from annoying surroundings is a third indication. Sleeplessness, which is frequently a conspicuous symptom, gives us a fourth indication.

The prominent requirements, then, in these cases are: 1. Rest. 2. Proper feeding. 3. Seclusion. 4. Sleep.

How can we obtain these four requisites without overdrugging our patients? We must introduce some means by which an irritable body, that is unable to assume the recumbent position without resting upon some painful spot, may lie down without pain. We must feed properly a patient whose appetite is capricious, whose stomach may be irritable and rebellious, whose bowels will not 'agree' with any thing that is suitable to sustain life. We must put into seclusion patients who imagine they require the sustaining sympathy of innumerable dear ones. We must produce sleep in a class of patients who have long ago worn out all the safe and efficient hypnotics.

I have had experience enough with these cases to satisfy myself that permanent cures can very often be effected by a line of treatment that has been practiced so successfully in general neurasthenia by that eminent Philadelphian, S. Weir Mitchell. While Dr. Mitchell was the originator of this systematic line of treatment, of which I can only hope to give merely an outline at this time, it has been adopted with great success by others, and by none with greater success than Playfair, of London.

Dr. Mitchell seeks to meet the four requirements in the treatment of these cases by first getting full control and confidence of the patient. Without this first requisite, the case is a failure. After this is accomplished he makes the remaining part of the problem feasible by a combination of entire rest and of excessive feeding made possible by passive exercise obtained through the use of massage and electricity.

A physician, to treat these cases successfully, must have an eye to detail, possess at least the ordinary amount

of tact, perseverance, firmness, and good executive ability. The nurses employed should be educated, intelligent, strong young persons, who are able and willing to work, and who can make themselves very agreeable; who possess tact and firmness, the latter without sternness. They should understand and be capable of performing thorough massage, administer a vaginal douche properly, and be adepts at preparing tempting sick-room delicacies.

In further describing this system of treatment I will give, for the sake of brevity, the details of treatment of a typical case of the kind that recently came under my observation:

The patient, a young married lady in the better class of society, without children, had been treated for "womb difficulties" for three years by at least two St. Louis physicians, from which city she had recently moved to Chicago. She had gradually become worn out from unsuccessful local treatment, and was about to give up in despair. She was in an extreme state of anæmia; had been gradually reduced in flesh from 120 to 100 lbs. Menstruation irregular and painful throughout. Bowels never moved without assistance. Appetite gone, and what little food she could be induced to take remained like a load on her stomach and gave her considerable pain. Besides the loss of appetite and indigestion, she had considerable ovarian neuralgia, general pelvic hyperæsthesia, and intense sacralgia. She was also troubled with persistent insomnia.

Physical examination elicited no localized pathological condition. Uterus natural in size and location, and movable. Ovaries not enlarged, but very tender. While there was general hyperæsthesia in every direction from the vagina, there was evidently no cellulitis or peritoneal inflammation. The urine was normal.

The scheme of treatment mentioned above was explained to the patient, and she immediately acquiesced when advised to make a trial of it. Contrary to Dr.

Mitchell's advice, she was not separated from her family, there being but her husband, and he at home but a small portion of the day. Be it remembered she was unable to retain even a very little of the blandest food without distress.

She was immediately put upon an exclusive milk diet. The diet for the first day was laid down as three ounces of milk every three hours. She took at this rate, in the first twenty-four hours, twenty-one ounces of milk. The second day the amount was increased to twenty-eight ounces by increasing each allowance to four ounces.

The third day, as the patient was doing remarkably well and the stomach was free from pain, one ounce of thinly cut stale bread, well toasted, was given in addition to the milk that was due at the three regular meal times.

The fourth day six ounces of milk were taken every two hours, with double the amount of toast that was given the day before. All the dyspeptic symptoms had at this time disappeared, and the patient, notwithstanding the amount of milk taken, commenced to ask for her meals.

The fifth day she was allowed in addition to the milk, for breakfast, about one and one-half ounces of finely chopped steak of beef rarely broiled; this, with about one ounce of stale bread with butter, was taken with great relish, and without subsequent distress. At noon, on account of a little feeling of nausea, she had nothing except her regular milk diet. An afternoon sleep left her with an appetite for her supper. She was then given three or four raw oysters, with toast and a small cup of tea. This was taken with relish, and there was a disposition to take more.

The sixth day, on account of the patient exhibiting a slight disgust for the large doses of milk the allowance was reduced to four ounces, it being rendered more nutritious by making it one-third cream. Besides the twenty-eight ounces of milk and cream, she was given this day the juice from one pound of beef in three doses, at 10 A. M. and 3 and

8 P. M. Besides this, the patient took part of a cup of coffee and an ounce of bread with butter for her breakfast, a lamb chop for her dinner, with bread and butter, and raw oysters with toasted crackers and butter for 6 o'clock supper.

From this time on while the patient remained under treatment with me, she had no trouble, with judicious care in its selection, in retaining and relishing an incredibly large amount of food. She would take, besides three large meals a day, a quart of milk and cream, and the juice from one-half to one pound of beef.

The digestion and assimilation of this large quantity of food by an irritable alimentary canal was made possible by systematic passive exercise. The routine of treatment for the day in this case was as follows: At 8:30 A. M., or as soon as the patient had awakened, she was given a light sponge bath, her hair was arranged, and her milk and breakfast taken. At 9:30 A. M., if the bowels had not moved spontaneously, a small rectal injection of soap and water was administered. This was not found necessary after a few days' treatment. At 11 A. M. or thereabouts the patient was given general faradization with an idea of reaching all the motor points of the superficial muscles. The region of the colon, especially of the transverse and descending colon, with special efforts at stimulating the rectum, was systematically sought. This treatment required from three fourths to one hour's time. The patient usually took a short nap after this treatment. About 1 o'clock she was induced to take a light dinner, or more properly, lunch.

In the afternoon, if necessary, the nurse would interest the patient by light reading for an hour, if she were not inclined to sleep, which was frequently the case. At 5 o'clock a light, rapid sponge bath was administered, followed by gentle rubbing of the skin with a dry bath glove. This proceeding occupied thirty minutes, after which the patient was again allowed to rest for an hour. At 6:30 or 7 P. M. she was given her dinner. The milk, in the meantime,

had been administered at regular intervals throughout the day. After the dinner or supper the patient was read to or amused in some way, or if she was so inclined, allowed to sleep. Nothing, except the amount they eat, will astonish one more than the amount of sleep some of these patients seem to require.

At 8:30 or 9 P. M. the regular preparations for bed commenced. This began with a systematic massage which included all parts of the external muscular system, and occupied about one hour. The patient was then moved to a couch, given a large vaginal douche of hot water while in the recumbent position; her bed in the meantime was changed, and she was at last, after a hard day's work, in which she had been but a passive laborer, deposited in it for the night.

This patient remained under this systematic treatment for about eighteen days only, at the end of which time it did not seem necessary that she should be kept under such close observation longer. She expressed a very strong desire to go with her husband, who was about to make a business trip south. Inasmuch as she was, to all appearances, now perfectly well, I gave my consent to this arrangement. She could take and digest more food than she had been able to for years, without a dyspeptic symptom; her menstrual period had passed without a pain; the pelvic hyperæsthesia, while not entirely subdued, was much improved; the vaginal leucorrhœa was entirely checked. The patient had gained ten pounds in weight. Her skin was now ruddy and healthy in appearance, and she felt strong, well, and in the best of spirits when she left the city. I have since seen the patient, and she assures me that she is in the best of health, and she certainly appears so.

All cases, however, in which the treatment described here seems applicable, will not give the brilliant results that twenty days' treatment accomplished for me in the above case. Every symptom of importance here disappeared

after four days' treatment, and subsequently there was nothing left to accomplish but to increase the flesh and strength of the patient. The getting up was gradual; at the end of about the ninth day she was allowed to sit up in a large upholstered armchair for one hour in the forenoon. This was followed rapidly with greater liberty, and at the end of the fifteenth day she was about the room fully dressed; and at the end of the twentieth day was ready to travel.

Frequently grave complications are met in the treatment of these cases. Occasionally a patient has been thoroughly disgusted with milk on account of excessive use of it in previous treatments. Others have the impression that it "makes them bilious," and it is not taken on that account. By taking pains to explain that milk is one of the most perfect forms of food, and that it is an important factor in the successful treatment, most patients will be induced to try it in small, often repeated doses. There is occasionally a patient found who cannot take milk in the raw state; the taste is objectionable, and the stomach rejects it. In such cases milk will often be well received if prepared with Fairchild's peptogenic milk powder. This is also a valuable addition when the patient becomes tired of milk late in the treatment. Beef juice prepared after Weir Mitchell's formula, either raw or cooked, is sometimes a good substitute. Patients are frequently found who can take scalded milk who cannot bear it in the raw state; and, again, frequently if mixed with cream, when milk alone nauseates. Where this important article of diet is not tolerated under any disguise, other food must be adopted which will accomplish the same end. Here, in selecting a suitable substitute for milk from the long list of natural and artificial foods, is where the ingenuity and experience of the physician are heavily taxed.

Occasionally among these patients will be found one who requires an alcoholic stimulant. This is often indi-

cated where there are sudden attacks of nausea. Hoff's fluid malt often arouses a desire for food, if given three or four times a day in small doses; the hop principle often acting, in addition, as a pleasant hypnotic in these cases.

Where the bowels are not sufficiently stimulated by the manipulation and faradization to cause an evacuation daily, a capsule containing ext. nux vomica  $\frac{1}{4}$  gr., ox. gall. gr. ij. aloin  $\frac{1}{8}$  gr., or something similar, should be administered at bedtime.

In spite of feeding, rubbing, and faradization, patients are occasionally found whose insomnia will persist. These cases I endeavor to control by giving them a hypnotic in such a way that they are not aware of the fact, and are led to attribute the sleep to the treatment. A favorite method is to saturate a loose vaginal tampon with a solution of chloral in glycerine and insert it the last thing at night. Sufficient chloral is absorbed to produce sleep, and the local anodyne effect upon the surrounding organs is not unpleasant. This can gradually be reduced in strength as the effect of the general treatment is sufficient to make it unnecessary. I have found also the triple valerianate pill of quinine, zinc and iron, valuable in cases in this condition; asafoetida pills are sometimes valuable at this point.

The urine should be examined occasionally in these cases to guard against harm arising from the excessive feeding.

If iron is indicated it can be given in small doses advantageously, in fluid malt, or, in case malt is not an article of diet, in a capsule. For administration in malt citrate of iron, quinine, and strychnine in 1-grain doses make an elegant preparation.

Success, however, depends much more upon the attendance the patient receives than upon the selection of drugs. Massage is given here with the idea of producing as much tissue change as possible, and the nurse who can accomplish the best results in this direction, as indicated by the amount

of food taken and assimilated, is the greatest success. The faradization I do not usually entrust to a nurse, although an intelligent trained nurse can soon be taught to manipulate the faradic machine. The end sought here is simply to cause contraction of all the muscles of the body that can be brought under its influence, and to stimulate the circulation. For this purpose I place a large electrode under the two feet of the patient as she lies in bed with knees flexed; this electrode is attached to one pole of an ordinary interrupted faradic battery. At the other pole I attach a bifurcated cord terminating in two small hand electrodes, made to fit the palm of the hand in such a manner as not to interfere with the flexion of the fingers. A process of kneading or petrisage is performed over the surface of the body, dwelling particularly upon the motor points of the muscles, while the current is simply strong enough to produce an agreeable prickling sensation.

In this chapter I have not been able to do more than to give the merest outline of a treatment of a condition which we all often meet in practice. In citing the particular case I have, I did so because of its being a typical one of the kind, and one in which the complete treatment in its most uncomplicated form could be demonstrated as a success. From this any intelligent physician can readily comprehend the scheme of treatment, and can as readily understand how many difficulties might arise that would complicate the treatment, at the same time not necessarily prove insurmountable barriers to its ultimate success. \*

## CHAPTER XXVI.

### DYSMENORRHŒA AND AMENORRHŒA.

**Dysmenorrhœa.** Dysmenorrhœa, being a symptom of a variety of pathological conditions, and as many of which have already been considered, I must refer the reader to the appropriate place of each for detailed treatment while contenting myself with suggesting indications.

Painful menstruation arises from obstructions to the genital tracts, non-development or atrophy of the uterus, tubes and ovaries, inflammatory deposits, congestion of pelvic organs and neuralgia.

**Obstructive Dysmenorrhœa**, caused by narrowing of the cervical or uterine canal, by congenital pinhole os, by inflammatory stricture or stenosis of the canals, or by flexions, may be beneficially treated by electricity in some form. If caused by pinhole os, or by cervical or uterine canal strictures, galvanism employed as described for strictures (on page 198) should be applied. If caused by an acute flexion of the uterus which is of such long standing that the muscular tissues on the concave side of the uterus have become atrophied the coarse wire current of the faradic machine should be used with the intra-uterine bipolar electrode, in order to favor uniform muscular development of the organ. For this purpose I employ an electrode which is flexible and elastic, and which, after its introduction, will exert a constant force, in its efforts to straighten, on the flexed canal in a direction to overcome the flexion. It is well, too, at each application to straighten the organ, if possible, by bimanual manipulation. Thus, while the induced current is working to restore muscu-

lar equilibrium, by direct mechanical means the organ is being molded to its normal condition. As soon as the organ is restored, dysmenorrhœa, caused by this defect, must of necessity disappear.

**Dysmenorrhœa from Non-Development** of the uterus, tubes or ovaries must be treated by means of the coarse wire stimulation of the induced current as detailed in treating the subject of non-development and atrophy of the uterus. Dysmenorrhœa caused by partial development of the tubes, a condition which F. B. Robinson has frequently pointed out, is one which I believe may be benefited by the action the coarse wire current exerts on these organs.

**Dysmenorrhœa which is caused by products** of inflammation imprisoning the tubes and ovaries or by interstitial infiltration of the ovaries may frequently be cured, I believe, by the systematic and persistent employment of the galvanic current. It should be employed by applying an active electrode in the vagina, crowded well into the cul-de-sac of the side affected, or by the employment of an intra-uterine electrode, either of which should be negative and completing the circuit by the employment of a small abdominal or hand electrode in such a position on the abdomen as to cause the current to traverse the seat of the exudates. A current of 50 milliamperes may be employed. The treatment may be re-enforced by hot water douches, tamponades, saturated with reduced glycerine, iodine, etc.

Dysmenorrhœa caused by congestion of the pelvic organs may not be cured by electricity because of a permanently acting cause. Chronic constipation, as a result of inaction, leading to an impairment of the portal circulation, and inactivity of the bowel muscles may lead to pelvic congestions and Dysmenorrhœa. This condition we have seen (p 214) may be remedied by the stimulating effect of the coarse wire current employed by bipolar electrode in the rectum. Forms of congestive dysmenorrhœa, the causes of which are obscure or have ceased to act, can frequently be

relieved and cured by the systematic employment of intra-vaginal, intra-uterine or intra-rectal bipolar coarse wire faradism. The congestion is relieved by stimulating the muscular tissues of the pelvis, direct action upon the muscular coats of the blood vessels and stimulating the vaso motor system.

**Neuralgic Dysmenorrhœa** should be treated by the fine wire induced current. The intra-uterine bipolar electrode should be employed about three times the week before menstruation is due. If severe neuralgic pains should appear during menstruation, external faradization with the fine wire should be employed. Place one sponge electrode over the sacrum and the other over the seat of pain on the abdomen.

#### AMENORRHŒA.

Amenorrhœa, either of a local or constitutional origin, may often be beneficially influenced by the rational use of electricity. When amenorrhœa is caused by obliteration of the genital canals, of course electricity offers no remedy. Amenorrhœa caused by non-development of the uterus and tubes or from atrophy of these same organs where the ovaries are healthy and active, should be treated by the bipolar intra-uterine coarse wire induced current as described in detail (on page 211) for non-development of the uterus. It should be persisted in for several months if necessary, the applications being given as often as three times a week. General treatment, hot water douches and other stimulating local treatment should not be neglected.

Amenorrhœa caused by general constitutional disturbances which lead to anæmia, and where the anæmia has been relieved by appropriate general treatment, may be cured by the stimulating effect of the coarse wire induced current. Here the unipolar method may be employed with benefit. One pole, the positive, as an intra-uterine or intra-vaginal electrode may be employed and the indifferent pole in the

form of a hand sponge electrode, may be used on different portions of the surface of the body. In these cases accompanying anæmia I frequently give general faradization (see page 228) employing the intra-uterine or vaginal electrode instead of one under the feet or over the abdomen. Here general stimulation is effected coupled with a strong local influence where it is most needed.

## CHAPTER XXVII.

### EXTRA-UTERINE PREGNANCY.

The employment of electricity, according to A. Brothers, of New York, who has collected much interesting material on the subject, in extra-uterine pregnancy, dates back to 1853, when Bachetti resorted to electro-puncture with the faradic current and succeeded in arresting a tubal gestation. According to Garrigues (*American Gynæcological Society Transactions*, 1882), Braxton Hicks employed the faradic current for the purpose of destroying a three months' extra-uterine foetus in 1866, and abandoned it after three applications. His patient subsequently died from hæmorrhage as a result of vaginal puncture of the foetal sack. According to the same author, Allen, in 1869, treated a case with faradization, which recovered.

#### CASES.

In 1888, A. Brothers<sup>1</sup> collected forty-three cases of extra-uterine pregnancy which had been treated by electricity. Of this list "two were treated by electro-puncture, twenty-one by faradism, sixteen by galvanism, two by both currents and one by Franklinism; in the remaining cases either faradism or galvanism was used, but the reporter did not specify which. Two cases terminated fatally; the case of Braxton Hicks, as the result of subsequent puncture of the cyst five weeks later, and hence the fatal result cannot be attributed to the electricity; and the case of Janvrin, in

<sup>1</sup> *Amer. Jour. Obstetrics*, 1888, p. 479.

which hæmorrhage was induced from a ruptured artery on the sac-wall, which had spontaneously opened nine days previously." In cases of Mundé, Lusk, Gardiuer and Chadwick, alarming symptoms developed for a time but the patients recovered. "In all of the forty-three cases excepting two the foetus was killed. Of these, in the case of Hicks the method was abandoned after two trials; and in the case of Garrigues the foetus was displaced from the tube into the uterus where it continued to grow. In the cases of McBurney, Garrigues and Trush, the current set up contractions in the muscular layer of the fallopian tube, which resulted in the expulsion of the foetus into the uterine cavity. In the cases of Lusk and Chadwick the treatment was followed by suppuration in the sac and septicæmia."

The foetus in each case began to work its way out through a spontaneous opening in the vagina and this process being arrested, both patients recovered. In Lusk's Septicæmia case a previous puncture of the sac with an aspirating needle probably accounts for the infection.

In 1890 (*Journal Obstetrics*, page 113) Brothers continues his series with ten additional cases. Of these, two were treated by galvanism, both being cured; five by faradism, all being cured; three with faradism and galvo-puncture, one being cured and two dying.

Thus, to summarize Brothers' fifty-three cases, four terminated fatally, five were treated by electro-puncture, eighteen by galvanism, twenty-six by faradism, two by both currents and one by Franklinism.

Of the four fatal cases, one was treated by faradism and died as a result of a subsequent puncture of the cyst five weeks later (not properly death from electricity). One by galvanism in which the author, Janverin, acknowledges that laparotomy should have been performed because of suspected previous internal hæmorrhage. Two from electro-puncture.

In 1890 (*Ibid*) Dr. Brothers, in his article, gave the

result of his researches, by correspondence and otherwise, of the subsequent behavior of twenty-five cases which were under observation for periods ranging between one and eight years after the employment of electricity. At least fourteen of these cases were under observation for periods longer than three years. "In eight cases a thickening or distinct tumor is referred to as present at the time of the last examination; in nine cases the local condition is not mentioned, and in the remaining eight cases nothing was found. In Lambert's case the woman presented symptoms of suppuration, but this passed away in time and required no surgical interference. In none of the other cases did the tumor seem to cause the slightest inconvenience. In two of the cases a recurrence of the extra-uterine pregnancy took place years later; both were subjected to a repetition of the treatment, with a similarly fortunate termination. The condition of health of these patients when last seen, was quite satisfactory. Two of the patients (those of Cocks and Gardiner) were reported as suffering from symptoms in no wise different from those they suffered for years previous to the extra-uterine pregnancy. Six of the women went through one or two subsequent normal pregnancies, and one suffered a miscarriage.

#### DIFFERENTIATION OF CURRENT.

From an analysis of all reported cases we find four fatal cases. Of Brothers' collection of fifty-three cases, five only were treated by electro-puncture, and in the five cases are found two of the fatal ones. Then, when we remember that the other two fatal cases cannot be traced directly to electricity as the cause of death, we find the only unquestioned causes of death from electricity under the head of electro-puncture. Surgical experience would make any one hesitate to advise puncturing a suspected extra-uterine foetal sac under any circumstances, much more so when clinical ex-

perience had demonstrated that methods avoiding the puncture were equally efficient. There is no evidence that either the faradic or galvanic current by surface application is not an efficient foeticide. There is abundant evidence on the other hand, that they are both efficient and both free from the dangers which may result from electro-puncture. We are justified, therefore, I believe, in condemning electro-puncture as a method of conducting electricity through the foetal sac for the purpose of destroying the embryo in extra-uterine pregnancy.

Of the currents, the faradic or the galvanic, which should be employed? If they are equally efficient as a foeticide I should recommend the uninterrupted galvanic current, because of the possibility of administering it without causing clonic muscular contractions and thereby avoiding one cause of rupture. The faradic current or the interrupted galvanic current produces clonic contractions of the abdominal walls and undoubtedly contraction of the muscular coat of the tube in which the sac is located. If the primary rupture has occurred into the broad ligament, there is still danger from violent contractions of the abdominal muscles of rupturing the sac into the general peritoneal cavity. With an idea of determining the relative foeticidal value of the galvanic and faradic currents, I conducted experiments on incubating hen's eggs. (North American Practitioner.) My experiments demonstrated to my mind that galvanism, in doses which can easily be tolerated without an anæsthetic, is a much superior foeticide than a very strong faradic current. I should, therefore, because of the superior foeticidal effect of galvanism, the practicability of administering it without producing clonic muscular contractions, the possibility of accurately estimating and regulating its strength, unhesitatingly recommend it as the current to be employed in destroying the embryo in extra-uterine pregnancy.

To summarize, then: (a) Never employ the electro-puncture. (b) Galvanism is a more efficient foeticide than

faradism and may be employed with the minimum danger of rupturing the sac. (c) The faradic current, while it will destroy the foetus, is more painful, less easy to regulate and more liable to cause clonic muscular contraction and rupture of the sac than galvanism.

#### TIME OF APPLICATION.

Electricity, for the cure of extra-uterine pregnancy, should be limited to the first three or four months of pregnancy. As an *adjunct* to surgery it may be employed to destroy the foetus much later.

When the life of the foetus is destroyed during the first three months of extra-uterine pregnancy without infecting the sac, practically complete absorption of the product will occur in from six months to a year. If in some way the dead embryo and its surroundings become septic they are liable to discharge into the vagina, bowel or bladder as an abscess. Puncture, therefore, should be avoided because it increases the danger of sepsis.

When the foetus is destroyed later than the third or at the most the fourth month, a greater effort on the part of nature is required to make a satisfactory disposition of the mass, and for that reason surgical experience decrees that it should be removed from the body either before life has been destroyed by electricity or afterward.

As an adjunct to surgery, electricity may be employed to destroy the life of the foetus after primary rupture has occurred and secondary attachments have been formed. By destroying the life of the foetus several days before an operation is contemplated, the great blood supply to the tumor becomes materially diminished, the placenta separates and when removal is attempted it can be accomplished with much less danger from hæmorrhage.

#### METHOD OF APPLYING THE CURRENTS.

**The Faradic Current.** A vaginal electrode (Fig. 78)

should be attached to one pole of a faradic battery with about a medium secondary coil as the source of induction, and this electrode should be placed in the vagina in such a position that the uninsulated portion will come as near to the foetal sac as possible. A large sponge hand electrode (Fig. 55) attached to the other pole of the battery should be placed upon the abdomen and pressed well down by the hand over the foetal tumor so as to occupy a position on the opposite side of the tumor to that occupied by the vaginal electrode. The current should now be turned on gradually until the very limit of toleration has been reached, and continued for fifteen or twenty minutes. The applications may be repeated daily for three days if no untoward symptoms arise. Marked diminution in the size of the tumor, which will be apparent in three or four days, is a sign of destruction of life of the foetus. If no such sign is recognized, and, on the other hand, the tumor continues to grow at the end of a week from the last application, the patient should be put under an anæsthetic and the full force of the battery employed (battery Fig. 31) for ten minutes. If the full strength of the battery produces violent contractions and there appears to be danger of rupturing the sac, the dose should be regulated accordingly. Unfortunately, we have as yet no way of measuring this current. Repetition of applications such as that described above is not usually necessary.

**The Galvanic Current.** As the galvanic current is the more efficient, less painful, less liable to rupture the sac than the faradic current I am inclined to favor its use for this work.

The half insulated vaginal electrode should be attached to the negative pole of a galvanic apparatus and placed in position in the vagina so as to lie in as close contact to the tumor as possible. A clay electrode about four or five inches in diameter attached to the positive pole should be placed on the abdomen and pressed firmly over the tumor

in such a position that the greatest diameter of the tumor lies in a direct line between the two electrodes. By means of a gradual current regulator, great care being taken to avoid a break, the current should be slowly turned on until it registers 50 to 75 milliamperes. This can ordinarily be tolerated without an anæsthetic.

The treatment should last for five or ten minutes if no untoward symptoms arise. It may be repeated for two or three days in succession. If the tumor is found undiminished in a week after the first application, the patient should be anæsthetized and a current of 250 or 300 milliamperes should be administered. The surface of the vaginal electrode may be increased when a large dose is given, by covering it with moistened absorbent cotton. A 250 milliampere current may safely be depended upon, it seems to me, to destroy the life of the foetus in two or three sittings if the milder current should fail.

For destroying the foetus after three months, if the milder currents of 50 to 100 milliamperes do not succeed stronger currents, under anæsthetic should be resorted to. Five hundred to six hundred milliamperes are tolerated without serious consequences, and in stubborn cases of extra-uterine, such currents should be employed if required.

The galvanic current has been recommended and employed to hasten the absorption of the products of conception after the extra-uterine foetus has been destroyed by the same means. It should be employed in the same manner as for absorbing inflammatory deposits. (See page 194.)

The following summary, with a few additions, is similar to that appended to Brothers' article in *American Journal of Obstetrics*, 1890, page 126.

1. The risk of rupturing the sac of an extra-uterine pregnancy and causing death by internal hæmorrhage is slight. (Brothers.)

2. The uninterrupted galvanic current is more efficient, and less liable to cause rupture than the faradic. [Author.]

3. Suppuration of the dead foetal mass will not occur in cases before the third month (unless infected through puncture or other improper treatment).

4. Beyond the third or possibly the fourth month, electricity should not be used. (It may be employed as an adjunct to surgery after that time.)

5. Electro-puncture is to be condemned in all cases.

6. In cases of mistaken diagnosis, no harm is done by the electrical treatment.

7. Under galvanism or faradism, early extra-uterine pregnancy can be checked in its growth, and subsequently the product of conception will contract into an unoffending mass or disappear entirely. In all reported cases of less than three months' growth, there has been no subsequent trouble.

#### METHODS OF INDUCING ABORTION BY ELECTRICITY.

In the pages immediately preceding, we have considered the relative foeticidal powers of the faradic and the galvanic current. The weight of evidence seems to be in favor of the galvanic current, although where there is so much chance for discussion, we can confidently employ either for the purpose of destroying the life of the foetus in the early months of pregnancy.

In employing either current for the purpose of inducing an abortion, two methods may be considered.

1. Passing a strong current through the gravid uterus without entering it with an electrode.

2. Inserting one electrode into the uterine canal.

By the first method one source of infection is removed. A large vaginal electrode is inserted so that the active portion occupies a position well up behind the cervix. A large abdominal electrode is then placed upon the abdomen, in such a position that the current will pass through the largest diameter of the uterus. If the galvanic current is selected

a current of 100 ma. should be employed for 5 to 10 minutes. If the uterus does not respond in 24 hours, the dose may be repeated.

If the above method fails after two or three thorough applications there can be no harm in using a smaller dose, not more than 30 ma. without an anæsthetic, and interrupting it several times. Or it may be reversed several times in rapid succession. However, this will seldom prove necessary.

If the faradic current is selected, the same electrode should be employed, and a current from the fine wire coil used as strong as the patient will tolerate. As in extra-uterine pregnancy, an anæsthetic may be required in some cases.

When the method is selected in which one electrode is inserted into the uterus, a small flexible intra-uterine instrument should be preferred. This, after thorough disinfection, should be carefully inserted into the cervical canal, without, if possible, rupturing the membranes. After the electrode is inserted, proceed as by the other method. The traumatism inseparable with this procedure makes it more of an operation, and proportionately more effectual.

## CHAPTER XXVIII.

### VOMITING IN PREGNANCY.

Obstinate vomiting may often be relieved by electricity, either galvanic or faradic.

Vomiting in pregnancy, from its nature, is specially influenced by the rational employment of this agent.

Direct transmission through the sympathetic nervous system of unusual nerve impulses to the ganglionic center or center controlling vomiting as a result of uterine and ovarian irritation during the early months of pregnancy, before these organs have become accustomed to their new function must account for vomiting in pregnancy.

By the penetrating influence of electricity the triangular mechanism required to carry out a successful uterine vomit may be stayed at three points—the uterus, the cervical sympathetic, through which the medulla center maintains communication, and the seat of distribution of the efferent nerves—the stomach.

The influence required of the electric current in this condition is sedation. We can obtain a direct sedative effect from electricity in two ways, *first*, by the anoelectrotonic effect of the positive pole of the galvanic current, *second*, by the induced current furnished by the fine wire secondary bobbin of the faradic apparatus.

I have succeeded in stopping vomiting and nausea of pregnancy instantly by these methods of application:

1. Positive electrode of the galvanic current over the stomach, the negative on the spine, over the upper dorsal region.

By this method the sedative effect of the positive pole is exerted on the distribution or terminals of the efferent nerves. The electrode over the stomach should be the small hand electrode (Fig. 55), and the other or indifferent a large hand electrode. A current of from 20 to 30 ma. should be employed for ten minutes. It should be of sufficient strength to produce a sharp burning sensation at the negative pole.

2. Positive pole of the galvanic current over the cervical sympathetic ganglia, the other, or the indifferent, over the upper dorsal region of the spine. Here the standard electrode (Fig. 54) should be placed firmly on the neck, just posterior to the angle of the jaw, and just beneath the ear, while the indifferent pole may be attached to a large hand electrode. The current should be gradually switched on, and of sufficient strength (about 10 to 25 ma.) to produce sharp burning at the negative pole, and the application should last for 10 minutes.

3. Faradic current from fine wire. One pole over the stomach, the other in dorsal region of spine.

Two large flat sponge electrodes should be employed, and the current gradually increased in strength, maintaining the finest possible interruption. The strength should be determined by the patient's sensibilities, and never employ it strong enough to produce pain. These applications should last from 15 minutes to half an hour, if no unpleasant symptoms do not arise.

4. Faradic current—fine wire. One pole on sacrum, the other over stomach.

This method should not be employed unless the above three methods have failed, because of the danger of destroying the foetus. Large electrodes should be employed and the current gradually turned on and off. The application may last from 15 to 30 minutes if no bad symptoms intervene.

5. Faradic current—fine wire. One electrode to cervix uteri, the other on sacrum.

Only in desperate cases should this method be resorted to. Place a vaginal electrode (No. 78) so that the uninsulated portion will rest against the cervix, and apply a large sponge electrode on upper cervical and lower lumbar region. Turn the current on gradually, maintaining the finest interruptions, until the patient distinctly feels its benumbing influence. It should be continued from 20 to 30 minutes if no untoward symptoms occur. We must be thoroughly convinced that all other means have been exhausted before resorting to this last procedure, because of the liability of an abortion being produced by the close proximity of the current to the foetus.

The author has had considerable experience with electricity in vomiting of pregnancy, and in a few instances in vomiting caused by irritation of the uterus other than pregnancy, and its results have always been a source of unusual gratification.

The application may be given at any time, but select if possible periods of exacerbation. Frequently once in the morning if the sickness is particularly distressing at that time. If it is continuous no harm can come if the applications are given every four or six hours, until relief is permanent. Ordinarily relief comes instantly, at other times while the case may seem stubborn, it will yield with persistence.

Begin with the first method described if a galvanic apparatus is at hand. Next in value is the third method. Try all in turn, however, before giving it up. The method is rational, and a fair trial of its virtues will usually bring reward.

## CHAPTER XXIX.

### GALVANO-CAUTERY SURGERY IN GYNÆCOLOGY.

The galvano-cautery may be employed in all surgery on the uterus, vagina, urethra, rectum, not of a plastic nature. In removing new growths, excrescences, or hypertrophied tissues, its action is most satisfactory. It carries with its destructive power asepsis and perfect hæmostasis.

#### GALVANO-CAUTERY OF THE URETHRA.

**Urethra Caruncles** are often very easily removed by the galvano-cautery. If the little tumor has a contracted base, a small platinum loop may be thrown over it while it is exposed, and as the loop is tightened, the current is switched on and the caruncle removed. There is no hæmorrhage and very little pain. If the growth is not sufficiently pedunculated to admit of the above measures, the whole mass can be dissipated by attacking it with a blunt pointed electrode on its surface or with a knife electrode at its base.

**Venereal Ulcers** of the meatus or urethra are easily and conveniently cauterized with the galvano-cautery.

**Urethral Ulcers** of a non-venereal type, are frequently attacked with the galvano-cautery, either through an endoscope or urethral speculum.

**Urethral Polypi** are removed by the ecraseur electrode.

#### GALVANO-CAUTERY OF THE VULVA AND VAGINA.

**Venereal Ulcers or Excrescences** are advantageously removed by the galvano-cautery.

**Cancer**, when localized either in the vagina or of the vulva may be removed with the galvano-cautery knife. Care should be taken to go well beyond the diseased tissue in dissecting out malignant growth. It is claimed by good authority, that the cautery has a specific action when employed in this way, to prevent a return of disease.

#### GALVANO-CAUTERY OF THE UTERUS.

The galvano-cautery in the surgery of the uterus possesses special advantages in:

- (a) Chronic cervicitis involving the deep cervical glands.
- (b) Fibrous and mucous polypi.
- (c) Endometrium vegetations.
- (d) Cancer.

**Chronic Cervicitis** involving the deep cervical glands should be treated by the galvano-cautery with the special object of completely destroying the deep cervical glands. This can be accomplished, after first dilating the cervix, with the straight, round-pointed electrode, or by the curette electrode. The cautery should be applied until the characteristic albuminous secretion ceases. One application, if thorough, should suffice to cure this condition.

**Fibrous or Mucous Polypi** should be removed with the ecraseur electrode. After placing the wire around the pedicle the current should be turned on and the loop tightened until the pedicle is severed.

**In Endometrium Vegetations** accompanied with hæmorrhage, the galvano-cautery makes an efficient curette which is aseptic and bloodless. One of the smooth rounded sound like (slightly curved) intra-uterine electrodes should be employed, after dilating the canal with a Goodell dilator, all portions of the canal being cauterized until it is smooth and free from vegetations. The canal may be packed with iodoform gauze, as after an ordinary curetting.

## CANCER.

Pawlik reported in 1884, 136 cases of cancer of the cervix which had been treated by galvano cautery. The report covered a period of twenty-three years. The immediate mortality was 6.6 per cent. Of the remaining 136, 33 were free from return in periods varying from two to twenty one years. In 1889, Dr. John Byrne, of Brooklyn, at the Boston meeting of the American Gynæcological Society, reported 367 cases of uterine cancer treated by galvano-cautery, the observations extending over twenty years. The vaginal portion of the cervix was involved in 59 cases; the entire cervix in 81; cervix and body in 219; and the body alone in 8. His immediate mortality was less than one per cent. Thirty-six cases of the cervical cancers were kept under observation, and the average period of return was eight years and seven months; the disease in thirty of these, not having returned in five years. The exemption from return in the cases in which the body of the uterus was involved, was much less, the average time in the eight cases being two years.

In operating on cancer of the uterus with the galvano-cautery the one idea should be to get beyond the disease as far as possible. If the cervix alone is involved, the wire *ecraseur* electrode may be employed. The cold wire should be placed well up to the vaginal junction with the uterus, tightened so as to contract the tissues, and while the operator makes traction on the cervix with a tenaculum, the current should be switched on and the loop shortened until the cervix is severed. The drawing upon the cervix with the tenaculum causes the *ecraseur* as it severs the tissues, to reach constantly higher tissues, so that a cone-shaped cavity is left, the apex extending upward into the uterus corresponding with the canal. If the disease has extended further into the uterus, after the cervix has been severed, as above described, the interior of the uterus can be still further re-

moved with the knife or pointed electrode. Get beyond the disease, is the rule to be followed, if it is possible, and the many different forms of cauterizing electrodes, coupled with the skill of the operator, must be the means of accomplishing this.

## PART THIRD.

### CHAPTER XXX.

#### GALVANIZATION — FARADIZATION.

Galvanization is divided into (a) General Galvanization, (b) Central Galvanization, (c) Local Galvanization.

**General Galvanization** is applied by means of a stationary electrode placed under the patient's feet, attached to the negative pole, and one or two movable electrodes to be operated by the attendant, in applying the positive pole successively, to all other portions of the body. A large flat sponge electrode 8x10 inches (fig. 56, p. 106), or a plate of sheet lead or zinc covered with a moist towel or layer of moist absorbent cotton, may be employed for the foot electrode. A large flat sponge electrode (fig. 55, p. 106), or two smaller hand electrodes attached by means of a bifurcated cord to the positive pole may be employed for the movable electrodes. The hand of the operator may be employed for the movable electrode—the current passing through his body. The patient during the séance may lie or sit. If in the recumbent position, his knees should be flexed so as to bring his feet in contact with the foot electrode. The operator should then begin with a minimum current at the head. In order not to shock the patient the hand should be employed as the electrode for the head and by means of a gradual rheostat (p. 88), apply the electrode with the current at zero, and gradually increase it until perceptible.

After carefully passing over the head, the sponge electrode should be substituted for the hands. A current of from 1 to 2 m. a. is of sufficient strength to begin with on the head. Over other portions the strength may reach a maximum of 15 m. a. A sitting should occupy from 5 to 30 minutes, according to the effects desired.

**Central Galvanization** is applied by placing a large stationary electrode over the epigastrium attached to the negative pole, and applying the movable electrodes, as in general galvanization—first from the head to the center of the body, second from the feet to the center of the body. The same electrodes for the active and passive poles may be employed as for general galvanization.

**Local Galvanization** is considered in Chapters from p. 108 to p. 204.

#### FARADIZATION.

Faradization may be divided into (a) General Faradization, (b) Local Faradization.

**General Faradization** implies application of the faradic current to the entire surface of the body. A large flat sponge electrode is placed under the patient's feet, and small hand electrodes in the hands of the operator traverse the patient's body from the base of the head to the feet. The current is regulated in strength to meet the varying sensibilities of the parts to which it is applied. In general faradization the head is seldom included in the circuit, and when it is, a very weak current should be employed. There is no means yet devised for measuring the faradic current. Different machines have their own peculiar mechanism for varying the strength of the sittings, therefore each case must be a law unto itself.

#### MINOR METHODS OF LOCAL GALVANIZATION.

**Longitudinal Brain Galvanization.** Standard electrodes, one attached to positive pole over forehead, one attached to negative over occiput. Weak currents, labile or stabile application.

**Transverse Brain Galvanization.** Standard electrodes, one on either side of head, current very weak,  $\frac{1}{2}$  to 1 m. a., increased from zero to maximum with gradual controller, and decreased, when through, to zero without break.

**Diagonal Brain Galvanization.** Standard electrodes, applied to fronto-parietal region on one side and to occipito-parietal region of opposite side, and vice versa. Current weak, gradual and without shock.

**Spinal Galvanization** may be either longitudinal or transverse. In longitudinal galvanization one electrode (standard) is placed over cervical region, the other at some lower point on the spine. In transverse spinal galvanization one electrode is placed over some portion of the spine, while the other is applied over the median line in front.

## CHAPTER XXXI.

### ELECTRIC BATH.

A form of electrical treatment which is constantly increasing in importance, since private hospitals and sanitariums have become a fashionable necessity, is the electric bath.

The electric bath is but a very convenient and thorough method of applying general faradization, general galvanization and central galvanization, associated with the effects to be obtained from systematic baths of varying temperature. In the treatment of hystero-neurasthenia, or neurasthenia of any description, nothing varies the monotony so effectually for a patient, and at the same time enables her to get the beneficial effects of both electricity and the bath, as a well operated electric bath.

#### THE BATH.

In prescribing electric baths, besides the particular form of electricity to be employed, the temperature must be taken into consideration. Three forms are recognized: (1) The tepid bath; (2) the warm bath; (3) the hot bath. As an adjunct to these is the shower bath of different temperatures, often prescribed to be given at the end of the electric bath.

The tepid bath varies from  $80^{\circ}$  to  $95^{\circ}$  F.; the warm bath has a temperature of  $95^{\circ}$  to  $105^{\circ}$  F., while the hot bath varies from  $105^{\circ}$  to  $110^{\circ}$  F.

#### UNIPOLAR BATHS.

Unipolar baths consist of those in which one pole alone is connected with the water in the tub, while the other elec-

trode in the form of a rod above the bath is grasped by the patient, or in the form of a large sponge electrode is applied to different portions of the body by an attendant.

#### THE BIPOLAR BATH.

In the bipolar bath the water forms the connecting medium between a row of electrodes on either side or end of the tub and the patient, without the latter coming in

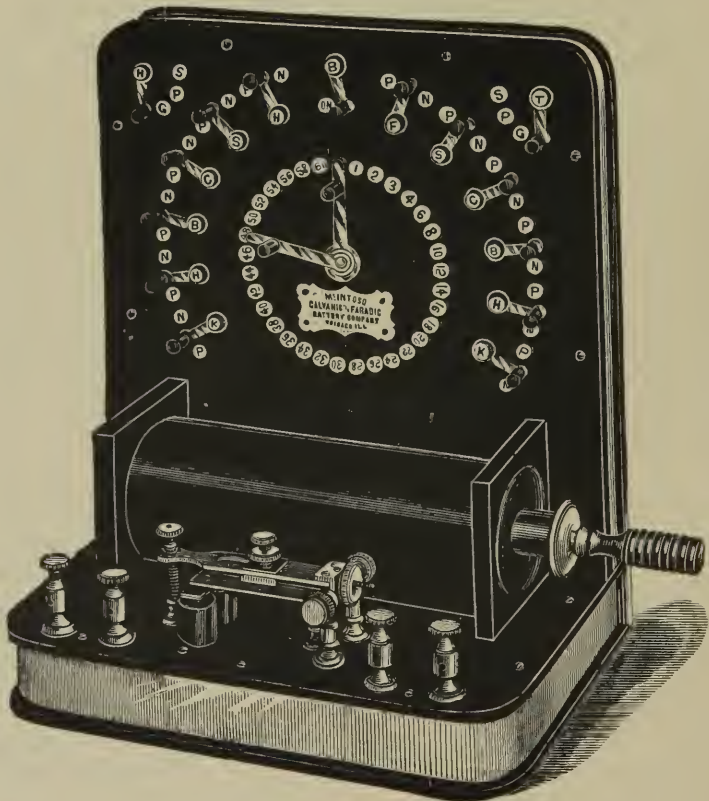


FIG. 81.

direct contact with the electrodes. A cross-current is when the electrodes enter the sides of the tub—the positive on one side, the negative on the other. A longitudinal current is when the electrodes enter the two ends of the bath tub.

A perfect bath apparatus is one in which there is provision for both longitudinal or lateral currents of either the faradic or galvanic current. Figs. 81 and 82.

**General Galvanization Bath** is best applied by making the electrode at the foot of the tub the negative pole, and allowing the electrode at the head of the tub with the two lateral electrodes nearest the head to become the positive. In this way a general descending current is applied to all portions of the body except the head.

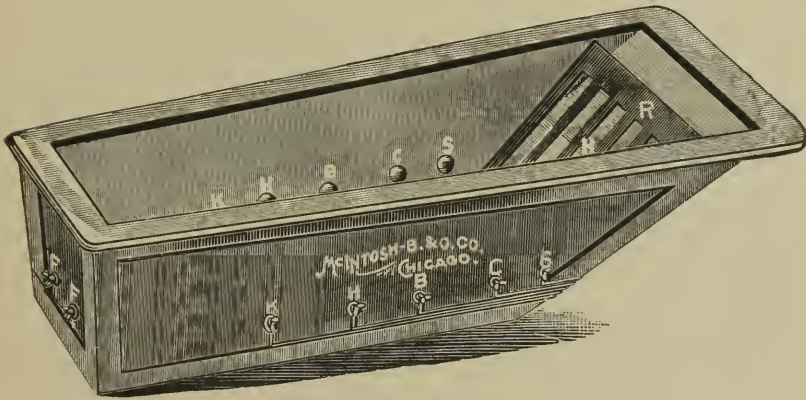


FIG. 82.

**Central Galvanization Bath** may be applied in two ways. First, by the unipolar method. Here a large sponge electrode attached to the negative pole is placed over the epigastrium, and the water of the bath is made the positive pole, by switching to all the electrodes in the sides and ends of the tub the positive pole of the battery. In employing general or central galvanization, the current should be started at its minimum strength and increased gradually until the necessary strength is obtained. Avoid shocks.

**General Faradic Bath** may be given by the unipolar or bipolar method. When by the unipolar method the water of the bath is made one pole, while by means of a sponge electrode attached to the other pole an attendant systematically applies it to all portions of the patient's

body. When the bipolar method is employed the foot electrode of the tub is attached to one pole, the head and lateral electrodes to the opposite. The switches should be arranged so that the current can be easily changed in direc-

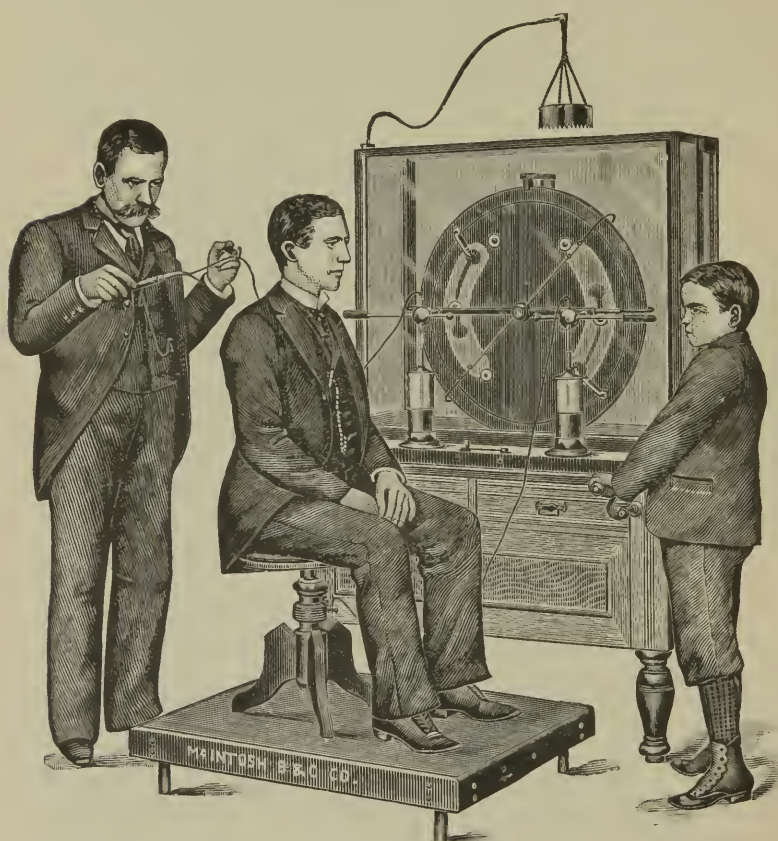


FIG. 83.

tion, by varying the polarity of any of the bath electrodes. The faradic current, when turned on, should be barely perceptible and then gradually increased in strength until the proper dose is obtained.

**Bath Sitzings** should vary in length from 5 to 20 minutes.

## CHAPTER XXXII.

### STATIC-ELECTRO-THERAPEUTICS.

Static electricity, its physics and its apparatus is considered in Chapter II. of this work. In the first edition of the book nothing more was said of this division of electricity, because it has no place in gynecology proper. Static electricity, however, is so often indicated as an adjunct to the therapeutics of the gynecologist that I have thought best to add a short chapter on the subject in the second edition.

#### METHODS OF APPLICATION.

Franklinization may be employed by four principal methods:

1. Static insulation.
2. Indirect and direct spark.
3. Static breeze.
4. Static induced current.

1. **Static Insulation** consists in insulating a patient on an insulated platform and surcharging his body with frictional electricity. The patient is seated on the platform, to which one pole of the static machine is connected, and the other pole is allowed to conduct to the floor or any indifferent object. The apparatus is now operated with vigor, the pole rods in the meantime being widely separated, until the patient is thoroughly saturated. As the patient rests on the insulated platform for a few minutes after the treatment is completed, a portion of the charge is lost to the surrounding atmosphere, and as he leaves the stool the equi-

librium is soon established between the patient's body and his surroundings by the charge passing to articles of furniture and other uninsulated objects.

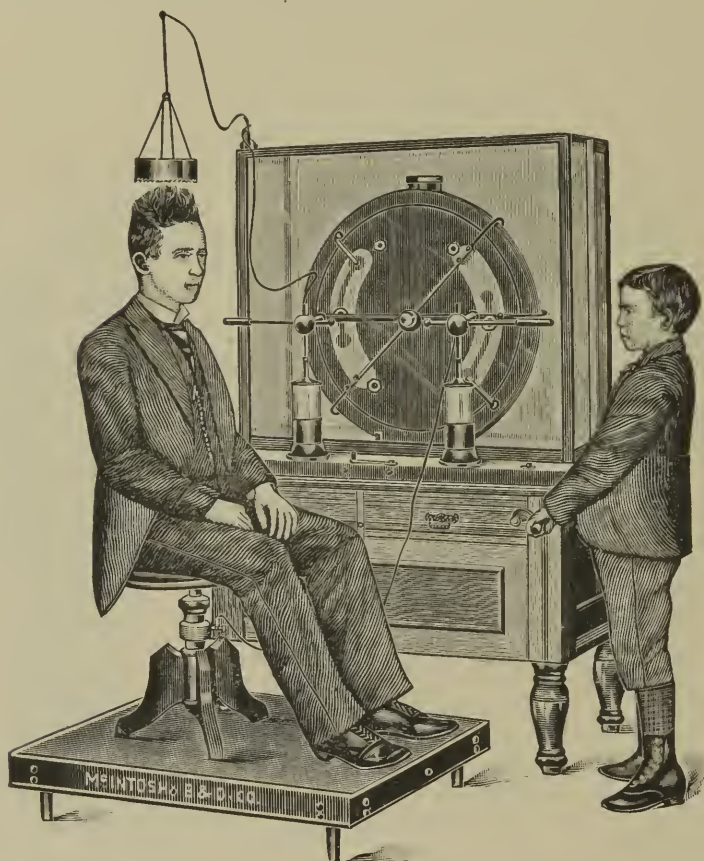


FIG. 84.

2. **The Indirect Spark** is obtained by bringing a ball electrode attached to some uninsulated object in close proximity to one charged by "static insulation." The electricity of the surcharged body will break loose with a rush, an audible break, and a brilliant spark, to be carried away by the uninsulated conductor. The "direct spark," or succession of sparks, is obtained by attaching the ball electrode

directly to the opposite pole to which the insulated platform is attached, and as the machine is operated bringing the ball near to the patient's clothing or skin. In this way a

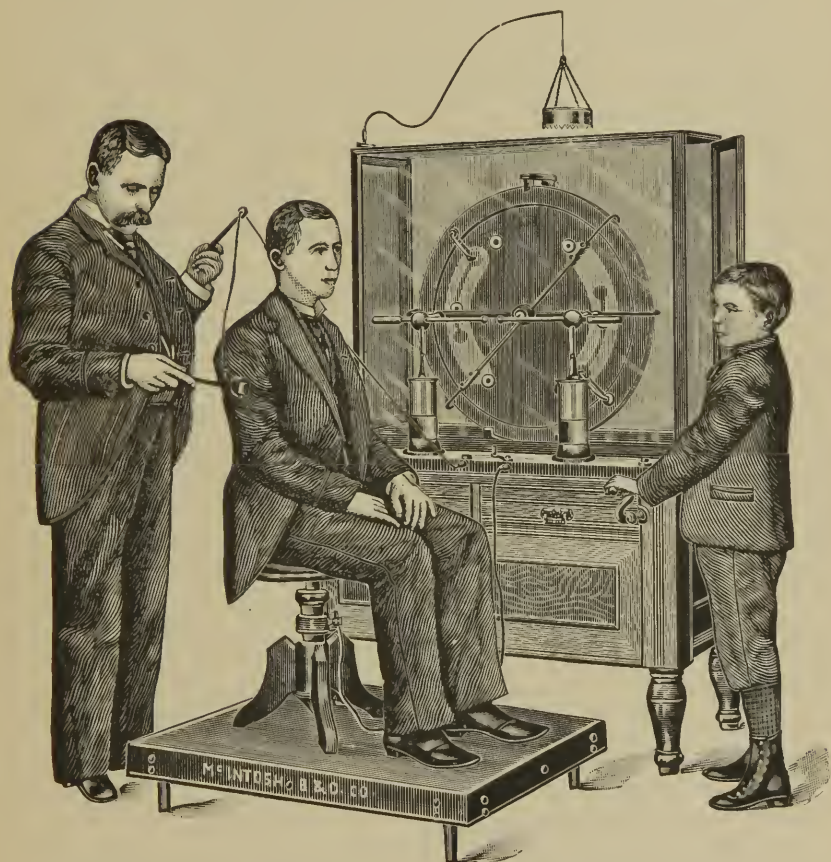


FIG. 85.

succession of sparks are obtained as long as the apparatus is operated. (Fig. 83.)

3. **The Static Breeze** is caused by passing a pointed electrode over the surface of any part of the body in close proximity to it without touching it, while the patient is in communication with the opposite pole through the insulated platform upon which he sits. This imparts the sensation

of moving air or wind. When it is necessary to apply the breeze to the head a crown electrode is suspended above the patient. (Fig. 84.) This is called the umbrella electrode.

4. **The Static Induced Current** is applied by means of two electrodes attached to the two leyden jars of the machine with the two pole rods (R. & P., fig. 6, p. 18) so closely approximated that a rapid succession of sparks passes between them. This gives a finely or coarsely interrupted current, according to the distance maintained between the pole rods, of very high voltage resembling very closely the induced or faradic current. (Fig. 85.)

#### PHYSIOLOGICAL EFFECTS OF FRANKLINISM.

The effects of static electricity may be enumerated briefly. It quickens the circulation, thereby promoting glandular activity. Body temperature is increased. All bodily functions are improved, as by a powerful general tonic. The effect upon the skin varies; at first it acts as a vaso-constrictor, afterward as a vaso-dilator. Perspiration is increased. Decided shocks occasionally produce wheals at the point of exit from the skin. The nerves of special sense are profoundly stimulated by static shocks. Its effects upon these important nerves, however, is of such an indefinite nature that it is seldom recommended as a therapeutic agent in their treatment.

The physiological effects of static electricity may be obtained in varying degrees, according to its methods of application. The mildest form is by insulation, the next stronger the static breeze, then follows the static induced, and finally the static shock is the most severe. The greatest advantage of the static form of electricity is its ease of application, there being no necessity of removing the clothing of the patient when the treatment is given.

## CHAPTER XXXIII.

### SUMMARY OF TREATMENT OF GENERAL DISEASES.

#### BRAIN.

**Anemia.** Local galvanization, longitudinal to brain with positive pole over medulla (vaso-motor center).

**Hyperemia.** General faradization of skin, or general faradic bath, or general galvanization or both with negative electrode under feet. Faradization of trunk and abdomen to act as a derivative.

**Chronic Meningitis, Sclerosis.** Brain galvanization for electrolytic effect in removing inflammatory exudates. General galvanization, spinal galvanization or general faradization for general tonic.

#### DISEASES OF MEDULLA.

**Chronic Bulbar Paralysis.** As relief measures, not curative, transverse brain galvanization may be employed. Stimulation of paralyzed muscles by galvanization or faradization. General galvanization or faradization for general tonic.

#### PSYCHOSES.

Liebig & Rohé,\* to whom I acknowledge much assistance in this summary, summarizes Arndt's conclusions of the electrical treatment of psychoses as follows:

"Functional psychoses are curable by electricity. Organic brain diseases accompanied by psychical disturbances may be improved in certain symptoms, but not cured.

"Early resort to this treatment, especially in mild cases, gives fair promise of success."

\* The Practical Application of Electricity in Medicine and Surgery.

The symptoms and methods of electrization is tabulated as follows by Liebig & Rohé:

SYMPTOMS.	METHODS OF ELECTRIZATION.
Insomnia.	{ Galvanization of the brain and medulla; general faradization; subaural and spinal galvanization; static electricity.
Melancholy, hypochondria, stupor.	{ Brain, subaural, and spinal galvanization; central galvanization; general faradization and localized application of the faradic brush (method of Vulpian); static electricity.
Katatonia, headache, precordial pressure.	{ Brain and spinal galvanization; general faradization; faradization of phrenic nerve.
Hysterical and reflex psychosis, beginning stages of progressive paralysis.	{ Galvanization of the brain; general faradization; subaural, spinal, and central galvanization; static electricity.
Hallucinations of sight and hearing.	{ Localized galvanization, with anode to affected organ.

#### GENERAL NEUROSES.

**Neurasthenia.** Under Chapter XXV., p. 221, neurasthenia of women is considered. The electric bath as a method of applying general galvanization and faradization may be employed. Static electricity as a general surface stimulant is indicated.

**Sexual Neurasthenia.** Static electricity, sparks from lower spinal region. Electric faradic baths, or general faradization.

**Spinal Irritation.** Longitudinal spinal galvanization with positive pole over sensitive area; same position of positive pole with transverse spinal galvanization.

**Hypochondria.** General faradization, static insulation; skin stimulation with faradic brush. Central galvanization.

**Hysteria:** Simply as an adjunct to other suitable treatment, general and central galvanization, either direct or by bath. Static breeze and static induced current. For the many local manifestations, and accompaniments of hysteria, the reader must be referred to other portions of this work. *Hysterical* aphonia often yields to transverse faradization of the larynx, or to transverse brain galvanization. Hystero-epileptic attacks may sometimes be broken by strong galvanic or faradic currents. (Liebig & Rohé.)

**Epilepsy.** Diagonal followed by longitudinal brain galvanization as a direct curative agent. Spinal, general and central galvanization, and general faradization as a general constitutional stimulant and tonic.

**Exophthalmic Goitre.** "Erb recommends spinal galvanization, transverse and diagonal brain galvanization to affect the medulla oblongata. To modify the exophthalmos, one pole is placed over the closed eye and the other in the auricular-maxillary fossa, or the current is passed transversely through the orbits." (Liebig & Rohé.)

**Chorea.** Static breeze or surface faradization.

**Athetosis.** Central galvanization.

**Vertigo.** Hot faradic bath, static breeze, surface faradic application.

**Writers', Telegraphers' and Piano-Players' Cramp.** (Liebig & Rohé.) Erb has laid down the rule that in these cases the entire cerebro-spinal nervous system from center to periphery should be subjected to systematic electrization. First brain, sub-aural, and spinal galvanization; then galvanization of the peripheral nerves and muscles. Faradization then of the affected muscles.

#### DISEASES OF SPINAL CORD AND ITS MENINGES.

**Chronic Spinal Meningitis and Pachymeningitis.** Spinal galvanization for curative local effect. General galvanization by sponge or bath for general muscular tonic.

**Locomotor-Ataxia.** Temporary arrest of progress

and frequent alleviation of symptoms may be looked for from electrical treatment in this disease. "Spinal galvanization, with galvanization or faradization of the peripheral nerves. Subaural galvanization and static electricity to the spine. Painful points are treated by placing the cathode over the painful area and the anode over the corresponding nerve-root. Lancinating pains and the girdle symptom are treated in the same manner. Rumpf lauds highly the application of the dry faradic brush to the trunk and extremities for ten-minute sittings daily, or every other day. The static spark is highly recommended in the lightning pains of Ranney. Swelling faradic currents (Far. <>) are also useful in the same symptoms." (Liebig & Rohé.)

#### NEURALGIA.

The indications for the electrical treatment of neuralgia, according to Liebig & Rohé, are: "1. To bring into action the electrolytic, vaso-motor and trophic effects of the current by the application of both poles over the seat of the lesion (if this is known). 2. The calmative effect; anode over painful spots, and cathode over the point of origin of the nerve or the plexus. 3. To obliterate the painful sensation by a momentary greater impression, reflex action.

**Trifacial Neuralgia** (*Tic Douloureux*): Temporary, occasionally, permanent relief. Galvanization: Positive sponge electrode over seat of pain for its anoelectro-tonic effect. Occasionally negative pole over painful area for its derivative effect, with sedative electrode over point of nerve exit from bone. Positive sponge electrode saturated with solution of cocaine, morphine, or atropia, placed over painful area, as a last resort, in order to obtain cataphoreses. Faradic current from fine wire secondary coil, over course of nerve. Static breeze.

*Cervico-occipital Neuralgia, Cèrvico-brachial Neuralgia, Dorso-intercostal Neuralgia, Lumbo-abdominal and Genito-crual Neuralgia*, are treated by the same general

principles as laid down above, viz: (a) Positive pole of the galvanic current over painful area, negative pole over origin of nerve or its exit from its bony encasement. (b) To be varied by employing negative pole over painful area for its derivative effect as a counter-irritant. (c) Pass galvanic current through seat of cause, if traumatic, rheumatic, or gouty origin, for its electrolytic effect. (d) Cataphoreses of anodyne drugs. (e) Weak faradic current from fine wire secondary coil. (f) Static insulation, breeze, or spark.

**Sciatica.** While neuralgia of the sciatica is rare, when occurring and of recent date it is susceptible often to the influence of electricity. After studying the particular case apply the principles laid down above.

#### PARALYSIS.

**Paralysis of Encephalic Origin.** Here we must seek to influence the circulation of the brain in order to modify the tendency to hemorrhage; and secondly, we must seek to remove the blood clot already formed. The first may be accomplished by galvanization of the cervical sympathetic. Place one electrode with considerable pressure behind the angle of the jaw and the other over the first or second cervical vertebrae. Employ a current gradually increased to a maximum dose of 5 to 8 m. a. for 10 minutes, then gradually reduce it to zero. To accomplish absorption of the clot, direct galvanization of the seat of the hemorrhage is desirable—first, to get the slight electrolytic effect; second, for the general tonic effect the current will have upon the nutrition of the parts. Longitudinal galvanization may be employed here, with the positive pole on the forehead and the negative at the base of the brain over the occiput. Great care should be employed to avoid a shock. A gradual current controller should be employed, and the current increased from zero to a maximum strength of  $1\frac{1}{2}$  to 2 m. a., allowed to pass for 5 minutes, and then carefully reduced to zero again. This treatment may be employed once in 24 hours.

While treating the origin of the paralysis, it is well to employ electricity for the purpose of maintaining the normal excitability of the muscles under the control of the diseased center, in order that they will be in readiness to take up the work as soon as the cause is removed and the will again sends forth impulses. Employ either the faradic or the galvanic current for the purpose of this muscular exercise, selecting the one to which the muscle responds most readily. Employ the weakest current which will accomplish the result. It is well to continue this muscular exercise by electricity until function is restored or until it is plain that the central disease is beyond remedy.

**Paralysis of Spinal Origin.** While the cause is sought for and if possible removed, the inactive muscles dependent upon the central condition should be exercised by electricity. Either the galvanic or the faradic current may be employed—the one to which the muscles will respond most readily. Mild currents should be employed. The applications should be made each day, until the central disease is removed, or until time has demonstrated that it is incurable.

**Paralysis of Peripheral Origin.** Facial paralysis should be treated with two objects in view. First, removal of the cause; second, stimulation of the muscles so that they may resume action as soon as the cause is no longer active. In facial paralysis, galvanism through the root of the nerve, faradization for muscular excitation. Facial paralysis of central origin should be treated under the principles laid down in treatment of paralysis of encephalic origin.

**Laryngeal Paralysis.** Place the positive pole (standard electrode) on spine below occiput, and the cathode (labile) up and down on either side of larynx. Employ galvanization, followed by faradization.

**Diphtheretic Paralysis.** With vigorous tonics, galvanization, general and central, should be employed. Small

doses and rather long sittings—10 to 15 minutes. The warm electric bath is an ideal method of employing electricity for this difficulty.

**Paralysis Agitans** may be beneficially influenced by combining with good general tonics, galvanization in small doses, either by direct application or by electric bath.

#### ANGINA PECTORIS.

Faradization during the attack is recommended. In the intervals, combined with other appropriate remedies, general galvanization should be employed.

#### ASTHMA.

Asthma of a nervous origin is frequently relieved by transverse galvanization of the spine. Faradization of the pneumogastric may be employed.

#### MUSCULAR CICATRICES AND SHORTING.

Galvanization for its electrolytic effect in removing inflammatory deposits combined with massage, accomplishes much in these conditions.

#### MUSCULAR RHEUMATISM.

Nothing yields to electricity in almost any form, as muscular rheumatism. In lumbago, one pole of the battery over the painful area, either of the faradic or galvanic battery, the other pole in some indifferent spot, or over the abdomen, in the hand, or on another portion of the spine, operated with a current of galvanism of 5 to 11 m. a., or a current readily born of the faradic variety acting from 5 to 10 minutes will give immediate and complete relief. In muscular rheumatism of other portions of the body, galvanic, faradic, or static electricity will accomplish like results. With the static variety one has the advantage of applying the electricity through the clothing of the patient. Electric baths have ideal effects in muscular rheumatism.



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